RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. XIV APRIL, 1930 No. 4

# FEWER VARIABLE FACTORS IN ROENTGEN THERAPY[1]

By ARTHUR W. ERSKINE, M.D., CEDAR RAPIDS, IOWA

ACCURACY is the prime essential in roentgen therapy. It tends to prevent over-dosage and under-dosage. The dangers of over-dosage are constantly in our minds, but the dangers of under-dosage have been given slight attention. Over-dosage may result in permanent injury to the patient but under-dosage may take away his only chance for life.

In this country, the great majority of roentgen-ray treatments are given, and must continue to be given, by roentgenologists whose offices are equipped with 10-inch transformers and Universal tubes. For some years at least, delicate and accurate measuring instruments will not be in common use. Since the degree of accuracy in roentgen therapy can be considerably increased by limiting the number of variable physical factors, the three combinations of factors, called, for convenience, Technics I, II, and III, as shown in Table I, are suggested as a basis for a simple routine technic. Variations in physical factors can affect only intensity, hardness, and distribution of the beam of roentgen rays, and these combinations seem to cover a wide enough range of hardness and distribution to meet the requirements of ordinary conditions suitable for treatment.

TABLE I

| Technic | I | II | III |
|---|---|---|---|
| Kilovolts (peak) | 135 | 135 | 135 |
| Milliamperes | 5 | 5 | 5 |
| Anode-skin-distance (cm.) | 25 | 25 | 40 |
| Aluminum (mm.) | 1.0 | 1.0 | 1.0 |
| Copper (mm.) | | .25 | .25 |

High voltage is desirable in deep therapy because it improves the homogeneity of distribution and shortens the time of exposure (Fig. 1), and in superficial therapy because it shortens exposure time. The voltage should be as great as the capacity of the tube will permit: 135 kilovolts is selected as the voltage common to all technics, because, while it is close to capacity, tubes can be operated economically at this potential over long periods of time.

The anode-skin-distance of 25 centimeters in Technics I and II is selected because it is great enough to modify the danger of sparking to the patient from the tube terminals and because it is short enough to permit a dose to be given without excessive waste of time. In order to obtain greater homogeneity the anode-skin-distance in Technic III is increased to 40 centimeters, which, as shown in Figure 2, is approximately the limit of economical increase in anode-skin-distance.

A filter of one millimeter aluminum is used in all three technics. The reason for omitting an unfiltered technic is shown in

[1]Presented before the Section on Radiology, American Medical Association, July, 1929, at Portland, Oregon.

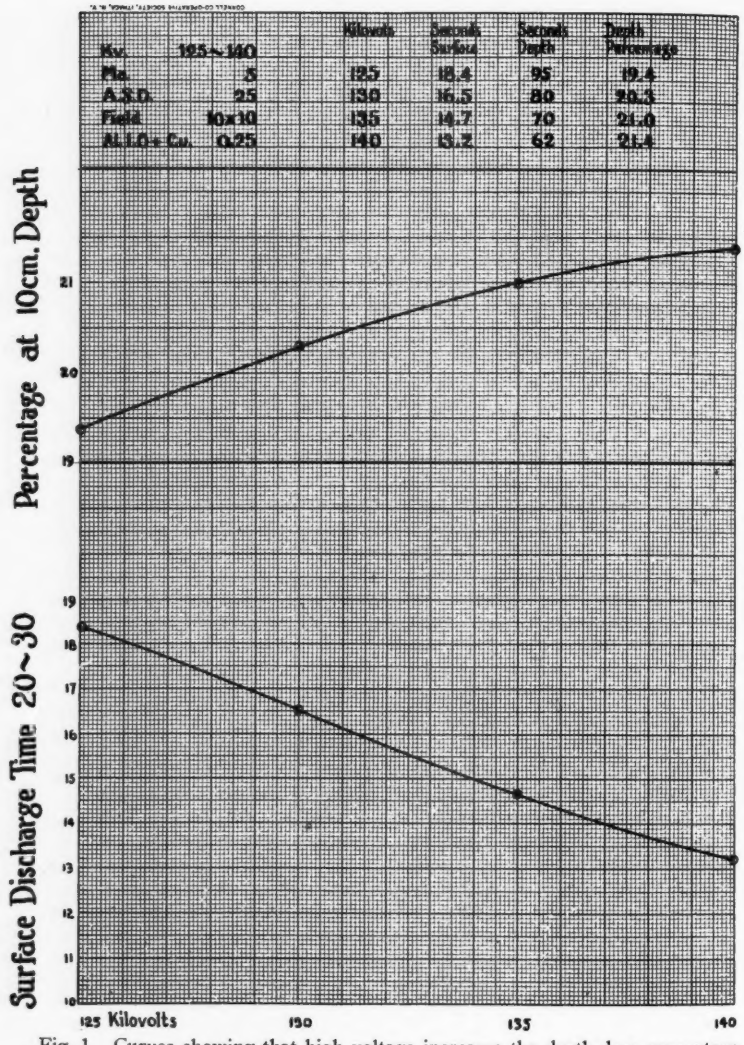



Fig. 1. Curves showing that high voltage increases the depth-dose percentage and also shortens the exposure time.

Table II, which illustrates the well known fact that unfiltered radiation from various tubes varies more than filtered radiation. Changing from an old tube with blackened walls and a pitted target, such as tube C, to the new thin walled tube D, would result in an over-dose of almost 100 per cent if no filter were used.

In Technics II and III a copper filter is added to increase hardness and to obtain a more nearly homogeneous beam of rays. A

TABLE II

VARIATIONS IN TUBES

| Tube | A | B | C | D |
|---|---|---|---|---|
| Average discharge time No filter | 5.5 | 5.6 | 8.6 | 4.4 |
| Percentage above or below normal | 0 | +.8 | +56.5 | —20 |
| Average discharge time 1.0 mm. Al. | 12.3 | 12.5 | 16.4 | 12.0 |
| Percentage above or below normal | 0 | +1.6 | +33.0 | —2.4 |
| Average discharge time 1.0 mm. Al. + 0.25 mm. Cu. | 50.5 | 51.1 | 63.2 | 49.5 |
| Percentage above or below normal | 0 | +1.0 | +25.0 | —5.5 |

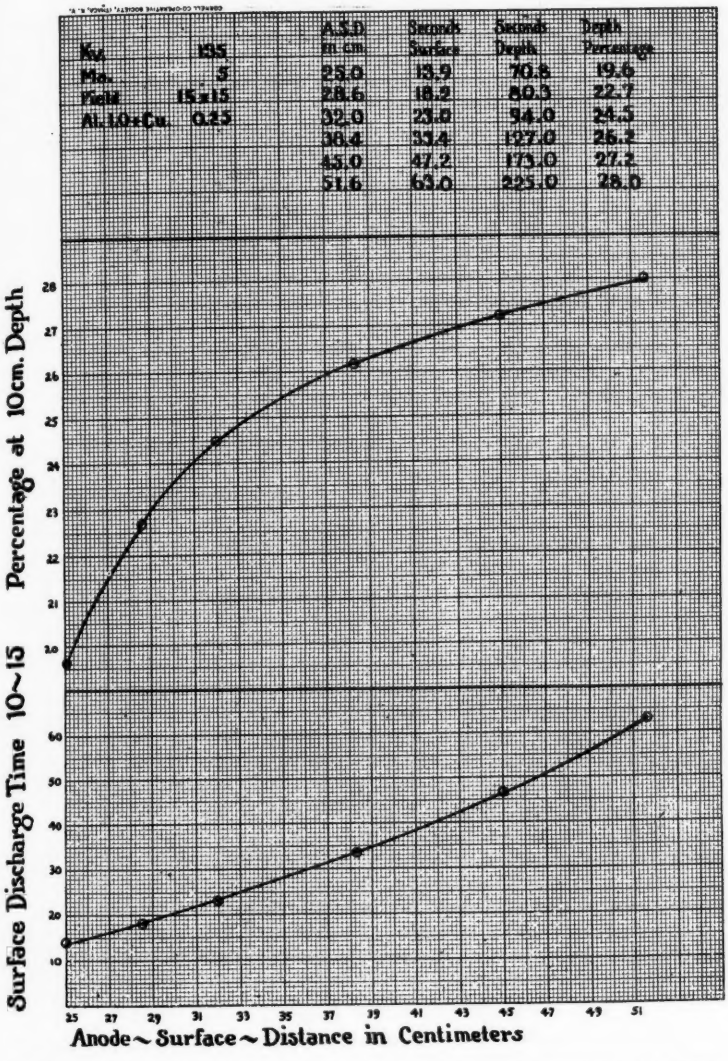



Fig. 2. Curves showing that a long anode-skin-distance increases the depth-dose percentage but lengthens the exposure time. The limit of economical increase in anode-skin-distance is about 40 centimeters.

thickness of one-fourth millimeter is used because the curves in Figure 3 show it to be very close to the limit of economical increase in filter thickness.

Hardness depends upon voltage and filter thickness. Distribution, however, is affected by hardness and also by the size of the field and the anode-skin-distance. Since a common voltage and only two filters are used in the three technics, there can be but two degrees of hardness. The half value layer in aluminum is 2.4 millimeters for Technic I, and 8 millimeters for Technics II and III (Fig. 4). It has not yet been decided that the biological effect of roentgen rays varies according to hardness, but if there is reasonable doubt that great variations produce different effects, it may cer-

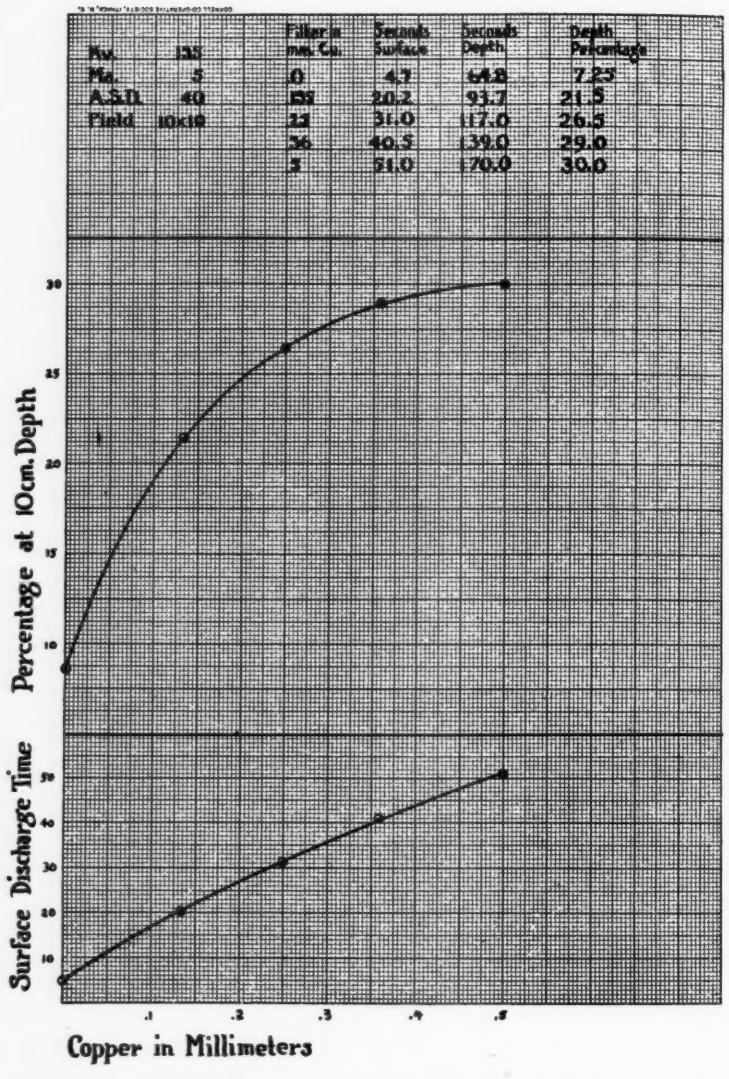



Fig. 3. Curves showing that a thick filter increases the depth-dose percentage but lengthens the exposure time. The limit of economical increase in filter thickness with 135 K.V. is about one-fourth millimeter of copper.

tainly be safely assumed that many small variations are unnecessary.

The combination in Technic I of 135 kilovolts and a filter of one millimeter aluminum produces rays of somewhat shorter wave length than those commonly used in dermatological practice. However, their hardness is not much different from that of rays produced by 100 kilovolts and a filter of two millimeters of aluminum or by 80 kilovolts and three millimeters of aluminum. The distribution charts of Technic I (Fig. 5) show that absorption is so rapid that there need be no fear of injury to subcutaneous structures. The distribution charts of Technics II and III can be used in esti-

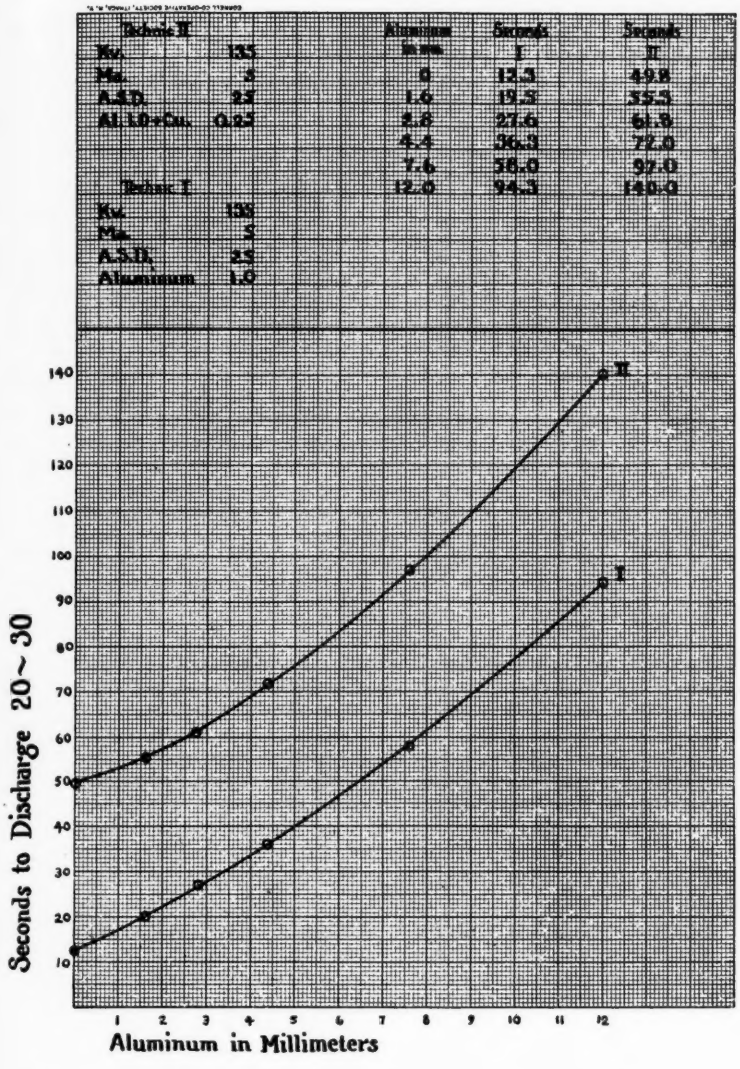



Fig. 4. Absorption curves. The half value layer in aluminum is 2.4 mm. for Technic I, and 8 mm. for Technics II and III.

mating the dose delivered to various depths, and as a guide in determining the number and size of fields to be exposed where cross-firing is necessary.

The relative intensity of the radiation produced by the three technics, measured in air and with various sizes of field, is shown in Table III. Since these measurements were made with an ionization chamber practically independent of wave length, they also show the relative time necessary to produce an equal biological effect.

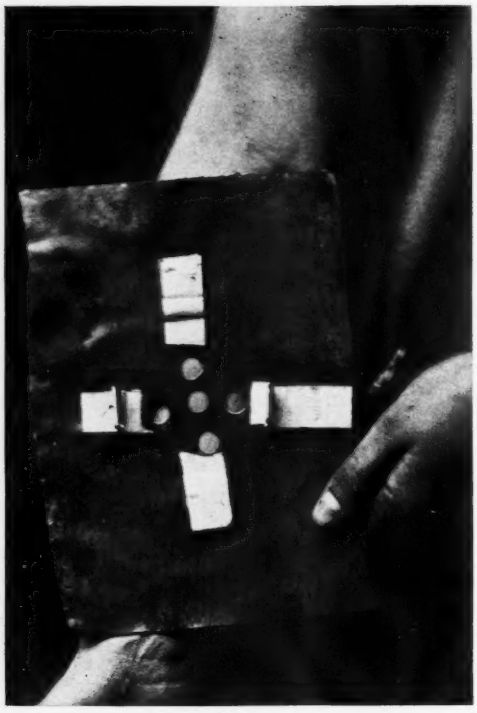


Fig. 6. To determine the minimum erythema dose time with Technics I and II small areas (1 cm.) of untanned skin are exposed various lengths of time. The length of each exposure is increased 20 per cent. The shortest exposure producing visible redness in five to ten days is the minimum erythema dose.

TABLE III

DISCHARGE TIME IN SECONDS WITH VARIOUS SIZES OF FIELD

| Size of Field in cm. | Technic I | Technic II | Technic III |
|---|---|---|---|
| In Air | 4.6 | 17.2 | 44.0 |
| 5 × 5 | 4.1 | 14.4 | 36.0 |
| 10 × 10 | 3.3 | 12.7 | 27.2 |
| 15 × 15 | 3.2 | 12.1 | 25.0 |
| 20 × 20 | 3.1 | 12.0 | 24.4 |

If an air-wall ionization chamber is not available, the relative intensity can be roughly determined by making "ladders" on photographic film, each step of the ladder being exposed a progressively longer time. The relative time required to produce equal blackening with Technics I, II, and III is one, four, and ten.

After fixing the factors of the technics and testing their relative intensity, the first step in developing a simple, safe working-technic is to determine the minimum erythema dose. The minimum erythema dose is the smallest amount of X-rays that will cause redness of the untanned skin, as compared with adjacent protected skin. A smaller dose must *not* produce redness. A simple method for determining the minimum erythema is shown in Figure 6. Areas of skin one centimeter in diameter on the flexor surface of the forearm are exposed progressively longer times. The shortest exposure-time producing redness is the minimum erythema dose, provided, of course, that at least one area has received a still shorter exposure without becoming red. A rather large number of such experimental exposures show that the average minimum erythema dose for untanned skin is 250 r-units.

TABLE IV

MINIMUM ERYTHEMA DOSE AND MAXIMUM SAFE DOSE IN r-UNITS WITH VARIOUS SIZES OF FIELD

| Size of Field in Cm. | Technic I | | Technic II | | Technic III | |
|---|---|---|---|---|---|---|
| | M.E.D. | M.S.D. | M.E.D. | M.S.D. | M.E.D. | M.S.D. |
| 1 × 1 | 250 | 2500 | 250 | 2250 | 250 | 2000 |
| 5 × 5 | 250 | 1500 | 250 | 1250 | 250 | 1200 |
| 10 × 10 | 250 | 1200 | 250 | 1000 | 250 | 900 |
| 15 × 15 | 250 | 1000 | 250 | 900 | 250 | 800 |
| 20 × 20 | 250 | 900 | 250 | 825 | 250 | 750 |

Table IV shows that the ratio between the minimum erythema dose and the maximum safe dose, as expressed in absolute units, is lessened very rapidly as the size of the field is increased. This change in ratio is a well-established clinical fact. It is much greater than can be accounted for by the increased back-scatter due to large fields as shown in Table III. A small area may receive a destructive dose and still recover, while a considerably smaller dose applied to a large area may produce permanent injury.

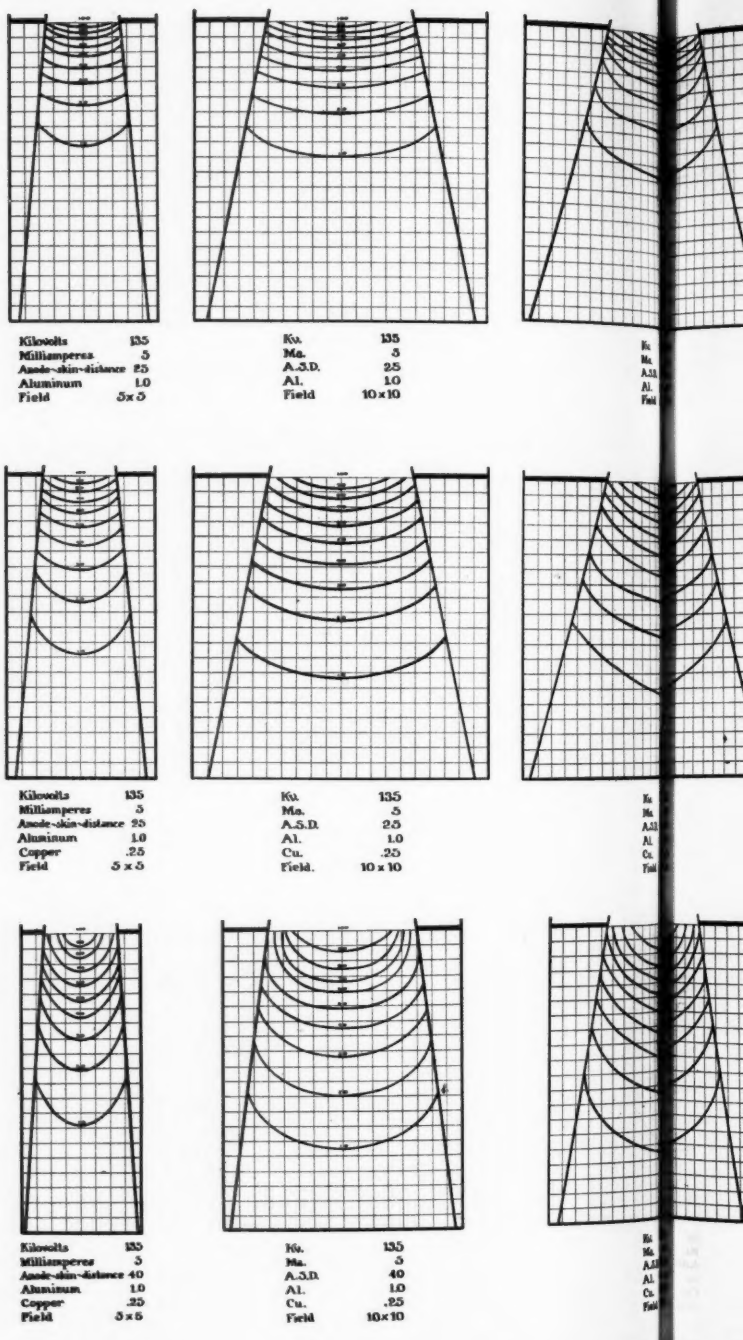
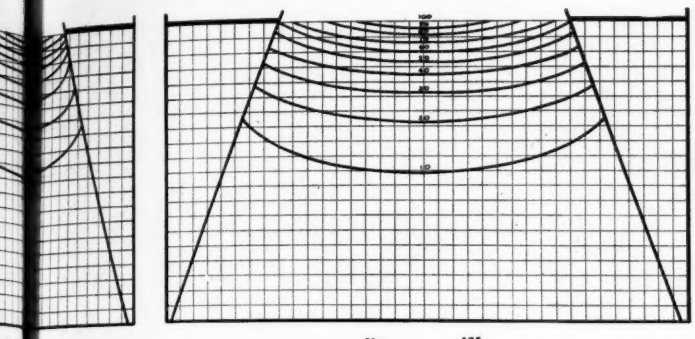
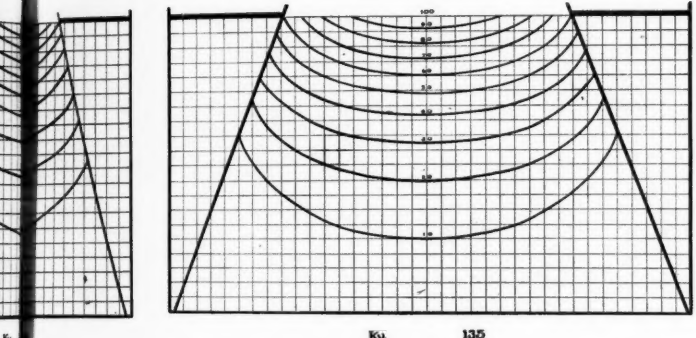


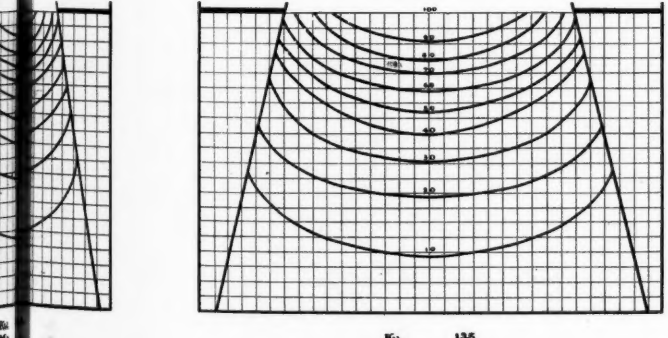

Fig. 5. Isodose charts showing the distribution in water of rays produced by t[illegible]chnics with to be used routinely in the treatment of superficial conditions. Technic II is intend[illegible]reatment percentage is adequate for deep therapy.



| | |
|---|---|
| Kv. | 135 |
| Ma. | 5 |
| A.S.D. | 25 |
| Al. | 1.0 |
| Field | 20 x 20 |



| | |
|---|---|
| Kv. | 135 |
| Ma. | 5 |
| A.S.D. | 25 |
| Al. | 1.0 |
| Cu. | .25 |
| Field | 20 x 20 |



| | |
|---|---|
| Kv. | 135 |
| Ma. | 5 |
| A.S.D | 40 |
| Al. | 1.0 |
| Cu. | .25 |
| Field | 20x 20 |

chnics with fields 5, 10, 15, and 20 cm. square. Technic I produces rays soft enough reatment of epitheliomata and subcutaneous lesions. In Technic III the depth-dose

TABLE V

RELATIVE TIME REQUIRED FOR THE MINIMUM ERYTHEMA DOSE AND MAXIMUM SAFE DOSE WITH VARIOUS SIZES OF FIELD

| Size of Field | Technic I | | Technic II | | Technic III | |
|---|---|---|---|---|---|---|
| in Cm. | M.E.D. | M.S.D. | M.E.D. | M.S.D. | M.E.D. | M.S.D. |
| 1 × 1 | 1.0 | 10.0 | 3.72 | 33.5 | 9.6 | 76.8 |
| 5 × 5 | .89 | 5.34 | 3.15 | 15.75 | 7.7 | 37.0 |
| 10 × 10 | .716 | 3.44 | 2.76 | 11.04 | 5.85 | 21.0 |
| 15 × 15 | .695 | 2.78 | 2.63 | 9.47 | 5.45 | 17.9 |
| 20 × 20 | .665 | 2.39 | 2.6 | 8.58 | 5.3 | 15.9 |

Table V is constructed from Tables III and IV and gives the relative time required for a minimum erythema dose and a maximum safe dose with the three technics and various sizes of fields. It must be remembered that the time-values are *relative*, not actual. However, if the actual minimum erythema dose for one or more combinations of factors is determined experimentally, a table of actual time-values can be constructed from it which will be clinically correct so long as the physical factors are unchanged and the efficiency of the tube is not impaired.

# THE ANALGESIC EFFECTS OF ROENTGEN RAYS

## WITH ESPECIAL CONSIDERATION OF BONE METASTASES OF CANCER

By J. BORAK, M.D., VIENNA

From the Zentralröntgeninstitut des Allg. Krankenhauses (Professor Holzknecht), Vienna
Translation from the German, by HENRY RIGGS WOLCOTT

THE analgesic, or pain-relieving, effects of roentgen rays are the subject of much discussion, though the discussion does not always reveal a correct insight into the factors controlling the problem. In viewing the effects of the rays solely from the standpoint of pain-relief and entirely apart from the pain-causing disease process, one comes sometimes to conceive of roentgen rays as possessing analgesic properties by virtue of their peculiar biologic action; that is to say, as if the pain-relieving effects were the direct and independent results of the biologic action of the roentgen rays. However, this conception of a certain specific analgesic action of roentgen rays, which has gradually taken on almost the nature of a fetish or shibboleth, can very easily be shorn of its investments and reduced to its basic significance by comparing roentgen rays with genuine analgesics. It will be at once apparent that, whereas genuine analgesics, such as morphine, as a type of a toxin affecting the central organs, and cocaine, as a type whose action is directed against the peripheral organs, may abolish *normal* pain sensation, or at least reduce it considerably—that is, act as a narcotic or anesthetic—such an action is impossible with roentgen rays. The proof of this requires no anatomic researches on the intactness of the sensory (as also of the motor) nerve terminals and nerve trunks, even after very heavy irradiations. Daily observation, and, if need be, a simple physiologic experiment, will show that therapeutic doses applied to the skin do not cause a reduction of pain sensations or of any other sensory perceptions (including temperature sense and sense of touch). However, in the case of a skin *damaged* by over-roentgenization, I have found that pain and temperature sensations are accentuated and touch sensations are reduced. The fundamentally different mode of action of roentgen rays and pure analgesics is thus made plain: *the roentgen rays can influence solely a pain that has arisen under pathologic conditions.* That fact furnishes the key to all further differences. Whereas, with pure analgesics, the effect becomes evident *immediately* after the application and continues only for a *very limited* time, the pain in various pathologic processes is checked by a roentgen irradiation after *varying periods of time,* and the analgesic effect continues a *varying length of time,* being sometimes *lasting.* The effects of roentgenization, therefore, never become evident within a few minutes, but only after the lapse of several hours, at the earliest, and usually after several days, and often only after a period of several weeks, and continue, even though they may be of a transitory nature, not only for a few minutes or hours but at least for several days, and usually several weeks—often several years; or, as already mentioned, the pain may be relieved permanently. Also the much greater variations in the range of dosage at which the roentgen rays exert an analgesic effect, as compared with the variations of purely analgesic remedies, furnish further evidence of their different mode of action.

From this short characterization it will be seen that the analgesic effects of the roentgen rays result only from the influence they exert on pain-producing pathologic processes; that the analgesic effects are exerted only to the extent that the cause that

underlies the pain is influenced, and that they are, in principle, only possible if it is possible to influence the pathologic process that causes the pain. In other words, *the roentgen rays act as an analgesic only when they act therapeutically; they act as an analgesic only so long and only to the extent that they exert healing effects.* The roentgen rays relieve pain, therefore, always in an *etiologic* manner; that is, by influencing the cause of the pain, and *not* merely *symptomatically* by influencing the pain-transmitting nerve conduction or the cerebral pain center; although, to be sure, they often do not act radically but merely palliatively—not lastingly but merely temporarily, and, in that case, they do not eliminate completely the cause of pain, or, at least, not the ultimate cause of pain, but influence only the immediate cause of pain; for example, they do not act upon the cancer itself but only on the secondary inflammatory infiltrate.

However, the great number of pathologic processes in which an analgesic action of roentgen rays may be observed will sometimes give the impression of a specific analgesic mode of action of roentgen rays. In seeming support of this conception is the fact that, very often, the pain-producing pathologic processes are not known, or, at least, are not known completely, so that the mode of generation of the roentgen action cannot be explained; or, at least, not fully. It is intelligible that, under these circumstances, one may frequently prefer to fall back upon a general analgesic property of the rays, rather than assume the trouble and the risk of analyzing the pathologic occurrences, which necessitates far-reaching special studies in the outlying fields of pathology, without much assurance of attaining any definitive result, as, for example, in dysmenorrhea, gastric ulcer, or trigeminal neuralgia. This condition of affairs explains also the fact that one often is induced, instead of explaining the effect of irradiation through reference to a definitely accepted cause of pain, to endeavor to ascertain the cause of pain by reasoning based on the established analgesic effects of the irradiation, as I tried to do, for example, with reference to Raynaud's disease (*Ztschr. f. d. ges. Neurol.*, Vol. III).

The relief of pain brought about by the rays is thus, as the pain itself, only a secondary phenomenon, which in every case occurs in the same manner; namely, through the primary influence on the pathologic process that causes the pain. The analysis of the analgesic effect of roentgen rays is thus reduced to the demonstration of an influence brought to bear on the process that lies at the basis of the pain. This influence can be expressed only as a partial or complete, transient or permanent, retrogression of the pain-producing pathologic process, independent of its nature. To demonstrate the mode of action of the rays in every case in which, after their application, a relief of pain is effected, especially in view of the aforementioned difficulties with regard to the explanation of the cause of pain in various affections, would require a whole volume, for such an undertaking would necessitate the analysis of the mode of action of the roentgen rays in most of the affections that are treated by this method.

We will therefore explain the mode of action of roentgen rays in the relief of pain in one example only. As an especially appropriate example we have selected the bone metastases of cancer; for the pains constitute the central feature of this affection, and we are able, as in scarcely any other affection, to demonstrate objectively, namely by means of roentgenograms, the described mechanism of the action that occurs in the relief of pain. Finally, we wish to call attention to the progress that roentgenotherapy has made in this field during recent years; for the matter is not as well known as it deserves to be.

Starting from that point of view, we find that it looks as if radiotherapy, in spite of

the fact that gradually it came to be recognized as in its natural province in treating mainly inoperable tumors, so far as malignant tumors are concerned, and in spite of the further fact that the public has become accustomed to the idea that its effects are not completely curative but only palliative—it looks, I say, as if radiotherapy would have to call a halt before bone metastases, which are the most inoperable of all inoperable tumors.

It is well known that bone metastases point to a previous hematogenic transportation of the "seed" of carcinoma, and it is believed that, under these circumstances, radiotherapy must confess itself powerless. Therefore, to propose roentgen-ray treatment is regarded in many quarters as evidence of overweening conceit or as an expression of optimism uncontrolled by judgment. But is not every case of tuberculosis of the bone an expression of a hematogenic transplantation and yet nevertheless curable—completely and permanently curable? But even though the bone metastases, in contradistinction thereto, cannot be completely cured, is it not justifiable to use radiotherapy in bone metastases, by reason of its temporary benefit, just as in many other inoperable tumors or in leukemia, likewise incurable, or just as a palliative cranium operation is resorted to in inoperable brain tumors, a gastro-entero-anastomosis in inoperable carcinoma of the stomach, digitalis in decompensated cardiac defects, and many other therapeutic means in the long list of incurable diseases? There seems to be rather a tendency to put a patient with bone metastases into a care-taking institution, and to raise the daily dose of morphine to 0.2 gm., instead of subjecting him to a trial treatment with roentgen rays. Besides the reason mentioned, there is another that influences the situation, namely, the predominant belief among roentgenologists that bone metastases of cancer are especially resistant to roentgen rays. The widely different biologic behavior of the various bone tumors toward roentgen rays is, unfortunately, insufficiently known, and, for that reason, the bad results that roentgenotherapy has recorded against it in primary bone sarcoma are transferred, without distinction, to all other bone tumors, including the metastases. And likewise, the unsatisfactory results of roentgen irradiation in other types of carcinoma and carcinoma metastases in other organs are extended to the metastatic carcinomas located in the skeletal system. In Rieder-Rosental's textbook, 1922, Vol. III, Kaestle expresses the view that prevails in the German literature in regard to the prospects of roentgen irradiation in bone metastases of cancer, when he states: "Cancer metastases are *per se* a manifestation of unfavorable prognosis, and though one may occasionally succeed in eliminating such metastases either definitely or temporarily (for example, in the ribs, in the hollow bones from cancer of the breast—not at all a frequent achievement), the patients, being permeated with the seeds of cancer, still succumb to their disease." While admitting the correctness of the beginning and the end of this statement, I must, on the basis of my observations, concerning which I published a first report in 1926 (*Archiv f. klinische Chirurgie*), oppose most vigorously the idea that only "occasionally" can one hope to eliminate a bone metastasis and that it is "not at all a frequent achievement." Kaestle's statement, with regard to bone metastases of cancer, is likewise quite contrary to my experience. He says: "They are only to a slight extent sensitive to roentgen rays, and, in order to influence them, they require, at least in the majority of cases, larger doses of the hardest rays than are needed for sarcomas." *On the contrary, bone metastases of cancer* are

much more sensitive to roentgen rays than most bone sarcomas. In America, to be sure, this fact has been recognized for some time. At this point, I am constrained to cite from Pfahler, who looks back many years to his previous activities in this field, and in his article (*Acta Radiologica,* 1926) makes a pronouncement that sums up all that can be said about roentgenotherapy as applied to bone metastases: "If there were primary bone cancers, we should have in them one of our most brilliant indications." We must add, however, only in case primary bone cancers behaved in the same manner as bone metastases of cancer; for the bone metastases of cancer are tumors *sui generis* (which has hitherto been entirely overlooked, though, from a radiobiologic point of view, it is of fundamental importance), since the skeletal system is a tissue which has no epithelium and consequently can never be the point of origin of primary carcinomas. If we add that the skeletal system, as has been observed again and again since Recklinghausen called attention to it, very frequently is attacked by metastases, *all other organs* that, supplied with an epithelium, may be the point of origin of primary cancer *remaining unaffected,* that is further evidence for the peculiar biologic nature of these tumors. Putting these two facts together, we are forced to the view that the bone metastases of cancer are doubtless *comparatively weak and only slightly virulent carcinomas, which, as such, can find a place to develop only in the skeletal system, which lacks all means of resisting the invasion of the completely foreign tissue.* The fact that they frequently develop from very inconspicuous, minute, occult primary tumors and remain sometimes latent for years, points likewise to their biologic debility.

The results of roentgen irradiation, that delicate agent for testing the biologic vulnerability of the tissues, agree with these biologic properties of the bone metastases of cancer. I have employed roentgen rays in about seventy cases of bone metastases of cancer, most cases with multiple but several with generalized metastases. The number of irradiated separate foci was thus many times greater than the number of cases. I have found that these carcinomas, independent of the number of tumors, independent of the localization of the individual foci, and irrespective of the point of origin and the nature of the primary tumors, are, with few exceptions (which I will discuss later), *the most sensitive to roentgen rays* of any carcinomas with which I have come in contact. Consequently, they can be treated with a certainty of influencing them, such as is to be found only in skin epitheliomas, in which connection it should be borne in mind that, in treating skin carcinomas, usually much higher doses are employed than in bone metastases of cancer. Accordingly, the bone metastases of cancer belong to that minority of cancers concerning which all that is true that was unjustly asserted concerning all cancers. In them I found the statement confirmed that the so-called least cancer dosage (*Karzinommindestdosis*) (that is, about 90 per cent of the skin unit dose according to Seitz and Wintz, and Jüngling) is *"überindividuell";* that is to say, causes regularly a retrogression of the tumor, although I must qualify this sentence with the following two restrictions: in the first place, this dosage is not a therapeutic dose but is to be understood only locally; for, though it always produces a retrogression, that is usually not complete and therefore not usually lasting. To obtain lasting effects this dose must be frequently repeated. Secondly, doubtless much smaller doses would be effective; for example, half of the dose mentioned, though the improvement wrought would soon fade away.

The effect of the irradiation is evidenced

chiefly by the *relief of the pain.* We shall now turn again to the main question as to the nature of the analgesic effects of roentgen rays.

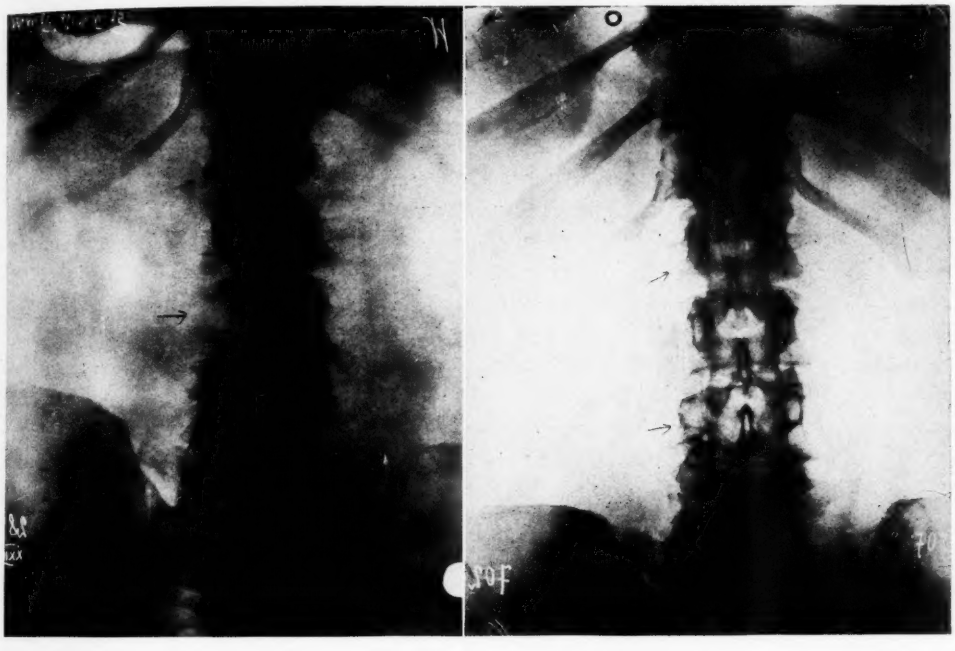
It may appear at first sight as a simple matter to explain how the pains associated with bone metastases *originate,* but in reality it is a difficult problem that is not yet fully explained. It will be considered here only so far as it is necessary for an understanding of the analgesic effects of roentgen rays. The presence of cancer tissue in the bones causes *per se* no pains. In fact, the metastases may be latent for a long time, and may even destroy the bone, without causing pains or other manifestations. As an illustration, let me cite a few pertinent details from the clinical history of a woman patient who, a half year after the operation for cancer of the breast, began to note pains in the legs—which proved to be caused by metastases in the spinal column. A thorough examination of the skeletal system resulted in the discovery of numerous metastases also in the region of the cranium, although the patient had not felt the slightest pain in the head. During the course of six months' observation, the metastases of the cranium underwent an extraordinary multiplication (Fig. 1), yet the patient remained still entirely free from pain or other symptoms in this region, nor was there pain on pressure.

Fig. 1. "During the course of six months' observation, the metastases of the cranium underwent an extraordinary multiplication, yet the patient still remained entirely free from pain or other symptoms in this region, nor was there pain on pressure."

This case shows that metastases, so long as they are localized centrally in the bone marrow and do not involve the periosteum, remain "silent"; that is to say, they may present anatomic but no clinical manifestations. Therefore, in roentgenologic examinations or at necropsies, they are often noted as secondary findings, similar to myelomas and other central bone tumors.

Bone metastases, then, do not reveal themselves clinically (the first warning is

usually in the form of pain) until the periosteum or nerve trunks adjacent to the bone become involved. Accordingly, two modes of origin of pain, or two different types of pain, may be distinguished in association with bone metastases. First, there are the pains that originate through immediate pressure of the cancer on the periosteum or on the nerves that supply it; that is to say, when the cancer, after destruction of the cortex, has reached the periosteum. The pains are then, not only in degree but also with respect to their immediate origin (motion, pressure, jolting), similar to those associated with incomplete fractures (infractions), to which especially Kienböck calls attention. Besides these traumatiform pains, which develop at the site of the bone destruction, there are (for example, if located in the spinal column) also radiating pains, especially frequent in the form of ischialgia. These neuralgiform pains arise from pressure of the cancer on adjacent nerves, for which in the narrow canals of the vertebræ an especially favorable opportunity is offered, and extend to all that portion of the body supplied by the nerve involved. They may appear also during rest and quiet, and are of varying intensity. The last mentioned fact gives rise to the suspicion that it is not the cancer tissue but the changing conditions adjacent to the cancer that are the immediate cause of the pain. In fact, one finds in anatomic control researches that the nerve trunks are by no means always surrounded by cancer tissue,



Figs. 2 and 3. Case 1. "A roentgenogram shows destruction of tissue on the lower surface of the first lumbar vertebra, and also in the region of the second and third lumbar vertebræ. In October, 1924, the patient was given a second irradiation, which was followed by a complete disappearance of the pains and increase of body weight, and she was able to perform the duties of her occupation for a period of two years. Then a tumor of the abdomen appeared, and there were pains between the shoulder blades, caused by metastases in the region of the cervical vertebræ. The patient died in February, 1927. The metastases in the region of the lumbar vertebræ had healed anatomically."

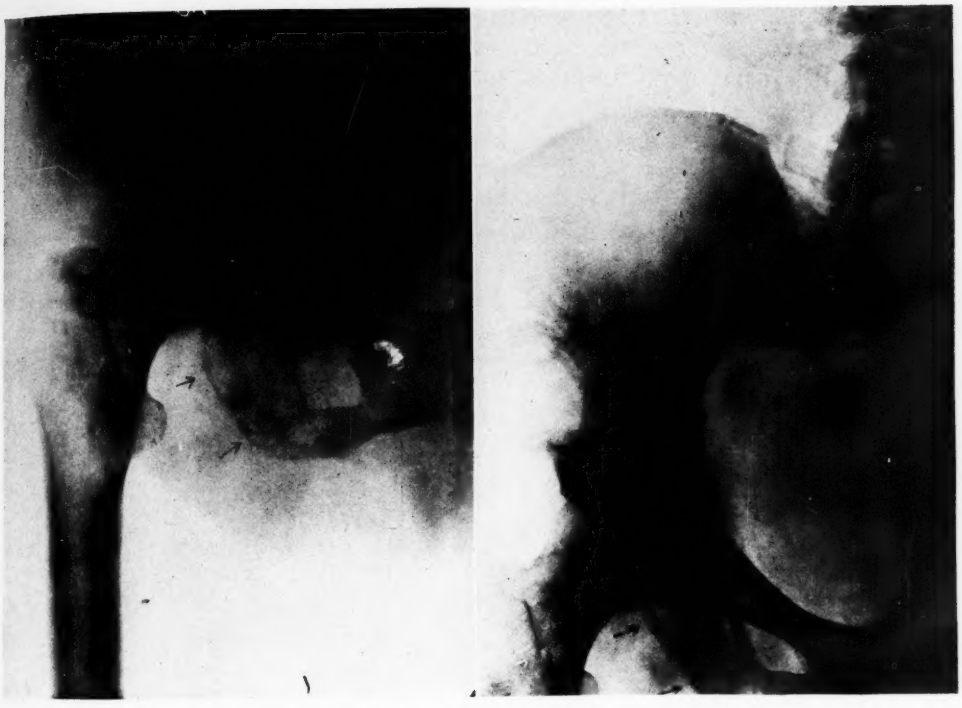
as one might imagine, although one does find that condition sometimes.

What distinguishes the pains associated with the bone metastases of cancer from the pains characteristic of fractures or neuralgias, in spite of the similar mode of origin, is the fact that they not only do not diminish but, on the contrary, constantly increase, or continually reappear in other parts of the body, since neither the carcinomatous infractions nor the carcinomatous neuralgias heal spontaneously or under the influence of otherwise active measures. The disorder, on the contrary, continues to progress, not only locally but also as it attacks other portions of the skeletal system, and consequently the pains associated with the bone metastases of cancer acquire their distinctive characteristics, namely, the nature of persistent pains. The pains from bone metastases may persist for not only weeks and months but for years; in fact as long as the patient continues to live. And, as the bone metastases often do not involve an organ absolutely necessary for life, the disorder may persist until either vital organs (such as lungs) are attacked or secondary complications (such as compression myelitis, cerebral embolism, pneumonia) cause a fatal issue.

Let us consider now the course of the described pain symptoms after roentgen irradiation is begun. If the patient has previously suffered for months, or possibly for years, from terrible attacks of sciatica, which could be controlled only by morphine in ever increasing doses—quickly, to be sure, but for ever shorter intervals—he will note a lessening of the pain after the irradiation; to be sure, not immediately afterward, but yet after a few days, or possibly during the series of irradiations. The pains abate first during repose, so that the patient can sleep for the first time undisturbed, through the night, without pantopon or other analgesics. Gradually he begins to notice that also slight movements can be performed without pain, and finally he makes the first modest attempts to walk, and, after from six to eight weeks, he finds his motor apparatus almost completely restored. After a time, he can again participate in long walks and hikes over the mountains; he can swim and dance, and after having been previously confined to bed for months and years, he gradually becomes able to work and to resume the duties of his occupation. Nor does the patient, as, for example, in leukemia, find it necessary to be irradiated again and again, but, on the contrary, if a second irradiation is given a few weeks after the first, he will require no further treatment at the site of the irradiation.

If we were able to prevent the genesis of further metastases, and particularly those that develop in vital organs, we might, under the impression of such marked results of treatment, hope even to effect a complete cure. Unfortunately, however, we can prevent the appearance of new metastases only to the extent that the irradiated foci may be conceived of as the point of departure of further metastases. But we never know whether or not, in addition to the already manifest foci, there are latent cancer seeds present in other parts of the skeletal system or in other organs, which may become manifest after a year or more. Prophylactic irradiations, as they would have to extend to the whole body, can seldom be considered of practical importance. Prophylactic examinations, in order that latent foci may be discovered before the clinical manifestation appears, have much more practical value, as we have had occasionally an opportunity to show.

How is this analgesic action, which is so surprising not only with reference to its initial effect but also by reason of its degree and its long continuance, to be explained? The action can certainly not be interpreted as a narcotizing effect on the central pain

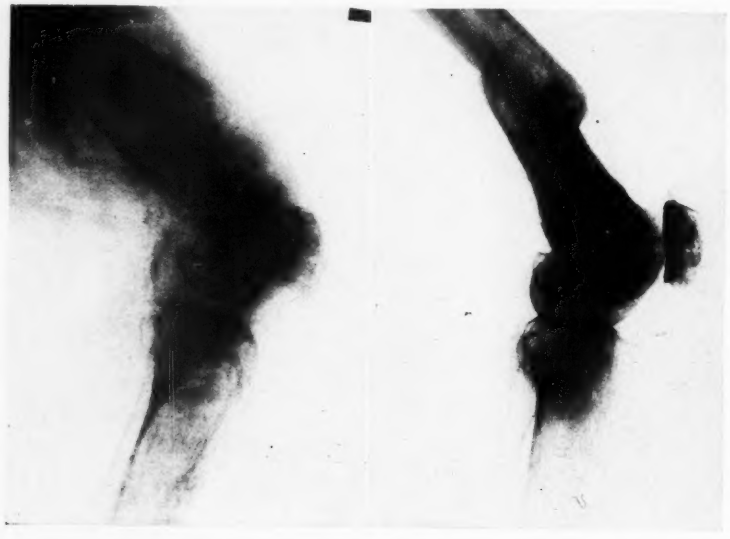


Figs. 4 and 5. Case 2. "The roentgen examination revealed: tumor metastases in the region of the lumbar vertebræ, a large focus in the region of the right iliac fossa, and numerous areas of lessened density in the left ischium. The examination was followed by irradiation. . . . The objective effect is shown in the roentgenograms above."

center, as is the case with morphine, or as an anesthetizing influence brought to bear on the pain-conducting nerves, as, for instance, in a paravertebral injection of novocaine; for the irradiation exerts its action only when it is applied locally, and, when the dose is properly adjusted, it has a lasting effect on the pain, which is entirely suppressed for at least a number of years. Therefore, it cannot be a question of a mere checking of the growth of the cancer but must involve a diminution or an elimination of the tumor tissue. We are thus forced to the conclusion that bone metastases of cancer may be made to retrogress under the influence of roentgen rays. That this is actually the case we can prove objectively by means of roentgenograms. A number of instances follow.

Case 1. The patient, Irma G., aged 47, was operated on, in 1921, for a left-sided, and in 1923 for a right-sided, adenocarcinoma of the breast. In February, 1924, she was irradiated, with good results, for skin metastases on the thorax and the epigastric region. In September, 1924, she complained of severe pains in the lower back region, with radiating pains in the thighs. Paresthesia in the legs was observed, and great uncertainty in the gait (compression myelitis, Wagner Clinic). A roentgenogram shows destruction of tissue on the lower surface of the first lumbar vertebra, and also in the region of the second and third lumbar vertebræ. In October, 1924, the patient was given a second irradiation, which was followed by a complete disappearance of the pains and increase of body

weight, and she was able to perform the duties of her occupation for a period of two years. Then a tumor of the abdomen appeared, and there were pains between the shoulder blades, caused by metastases in the region of the cervical vertebræ. The patient died in February, 1927. The metastases in the region of the lumbar vertebræ had healed anatomically (Figs. 2 and 3).



Figs. 6 and 7. Case 3. "Roentgen examination [of the lesion at the left knee] revealed its pathologic nature on the basis of a metastatic tumor. . . . Roentgen irradiation of the bone metastasis led to a sclerosing and consolidation of the bone fragments."

Case 2. The patient, Elise D., aged 52, was operated on in 1923, for cancer of the breast. In August, 1925, sciatic pains developed, which gradually became more severe until the patient was no longer able to walk. The left patellar tendon reflex was reduced, and the left leg musculature was rather atrophic. The roentgen examination revealed: tumor metastases in the region of the lumbar vertebræ, a large focus in the region of the right iliac fossa, and numerous areas of lessened density in the left ischium. The examination was followed by irradiation. Concerning the effect, the patient reported three months later in writing: "To-day I did not find it at all difficult to walk for two hours at a stretch, although, to be sure, I took a moderate pace. I have no sign of pain, except that, after sitting for some time, I cannot raise my legs so well, and, if the weather is bad, I have an aching sensation in my limbs, but aside from that I am perfectly well." (The objective effect is shown in Figures 4 and 5.) After seven months an exacerbation occurred. Another irradiation was given in October and still another in December, 1926, since which time the patient has again been without pain or other discomfort.

Case 3. The patient, Adele B., aged 62, had complained since September, 1927, of pains in the left knee, which at first were interpreted as due to arthritis and were treated accordingly. A year later a fracture was diagnosed. The roentgen examination revealed its pathologic nature on the basis of a metastatic tumor. At the same

time, a tumor was found in the right breast, which was extirpated and the site was afterward irradiated. Roentgen irradiation of the bone metastasis led to a sclerosing and consolidation of the bone fragments (Figs. 6 and 7).

In certain cases we were able to demonstrate the disappearance of the bone metastases anatomically also. We have already reported one of these cases (Case 1), to which we will add one more case, that of Mrs. Julie N., in whom, two years after an operation for cancer of the uterus, there developed an immense local recurrent tumor and, a little later, a tumor of the right lower leg, corresponding to which there was in the roentgenogram, in the region of the tibia, an oval area of lessened density, not sharply delimited, of the size of an almond. Two months after a single roentgen irradiation with the erythema dose, the aforementioned lighter oval area was seen to be surrounded by a dense zone, and the periosteum, in the form of a calcified strip, had separated from the bone. The patient died, two months later, from complications associated with the uterine cancer. The roentgenogram of the tibia showed that the area of lessened density had almost completely disappeared, and that, aside from the ossifying condition of the periosteum, only a slight bone atrophy remained. Neither the macroscopic nor the microscopic examination showed the presence of cancer tissue, and only the thickened periosteum revealed that a pathologic process had run its course. (Illustrations from the roentgenograms will be found in *Arch. f. klin. Chir.*, CXLIII, 1.)

To be sure, we shall not always be able to effect so complete a healing as is recorded in the foregoing case. Some carcinomatous areas will doubtless resist irradiation, as so frequently single cancers, and thus give rise to recurrences ("metastatic recurrences"). It may also happen that, if, in consequence of an injury of the periosteum by the cancer, the tumor undergoes changes only in the connective tissue, the bone regeneration cannot be demonstrated roentgenologically. Likewise, we shall be unable to demonstrate and follow roentgenologically the retrogression of an osteoplastic cancer, since newly formed bone, the same as normal bone, is characterized by a high sensitiveness to roentgen rays. It is certain, however, that the analgesic effects of roentgen rays in bone metastases of cancer, as the foregoing examples show, are not of a symptomatic nature but the expression of a genuine therapeutic action. Just as a skin epithelioma that has developed from an ulcer disappears and heals over, forming new skin, so a bone metastasis disappears and becomes recalcified, and thus also the pains disappear, as after the operative removal or radiotherapeutic destruction of a tumor usually associated with pain. Only the analgesic action in bone metastases of cancer, in consequence of the aforementioned biologic qualities of the tumor tissue, constitutes an irradiation effect that is almost as dependable as the influence of roentgen rays in leukemia; for there are very few exceptions to the behavior described. The exceptions concern cases in which the bone metastases of cancer have infiltrated the adjacent tissues for a wide area, and in which, entirely separate from the bone, large, palpable, and sometimes even visible, tumors develop. This occurs especially in connection with metastases in the region of the clavicle and the sternum. Hypernephroma metastases especially appear to have a tendency to take on such an aggressive nature. A diminution can, to be sure, be brought about even in these tumor-forming metastases, but a complete elimination of the cancerous focus is not effected.

With these exceptions, the bone metastases of carcinoma can, as was stated, be very favorably influenced by roentgenotherapy,

irrespective of their number, their localization, the site of origin, and the nature of the primary carcinoma. The pains disappear, and the cancer tissue is destroyed and replaced by newly formed bone. *The analgesic effects of roentgen rays are thus not of a symptomatic nature but an expression of genuine therapeutic action.* The appeal, "At least eliminate the pain," as is so often demanded, is not possible of accomplishment by means of roentgen rays. We must do either more or less than that. If we cannot influence the cause of the pains, we cannot eliminate the pains. But if we succeed in influencing the cause of the pains, we have then eliminated more than "at least the pains." The effect on the pains is measured, then, by the therapeutic action.

# INTRODUCTION TO THE SYMPOSIUM ON DOSIMETRY

During the past years, you have listened to many a paper on dosimetry, and I would not be surprised if some of you have felt that the space devoted to this subject by our Journal has been rather liberal. However, the importance of recording the dose applied to a patient is more and more recognized, and this is undoubtedly due to the fundamental work of the physicist, supported and encouraged by numerous radiologists who are interested in this particular field. All those who believe in the scientific administration of radiation therapy have welcomed the acceptance of the r-unit as the International Unit, during the International Congress, in Stockholm, in 1928. While this settled the problem in an official way, a good deal of the major work remains to be done, and that is the adaptation of the physical unit to our clinical work. This will be a slow process because so many practical questions arise. I will only refer, for instance, to the relation between wave length and skin toleration or erythema or skin unit dose expressed in r-units.

For many years, I have been keenly interested in the measuring of the radiant energy administered to a patient. I have always advocated that there are minimum requirements for the safe and accurate application of radiant energy to patients. Some time ago, I compiled these requirements in an editorial published in the *American Journal of Roentgenology and Radium Therapy,* grouping them under ten headings. Ever since this editorial appeared, some of my friends have kept reminding me of the "Ten Commandments." Nevertheless, it was with great pleasure that I accepted the invitation of our President to arrange a Symposium on Dosimetry. After careful deliberation, it seemed wise to stress the practical side of the subject. The first paper will present a brief history of the work which led to the establishment of the r-unit; the second, a very important study with a statistical background, will furnish you with average figures for skin doses expressed in r-units as used to-day in American clinics; the last paper will deal with the old problem of the combined effect of roentgen and ultra-violet rays on the skin.

In addition to these essays, there will be a demonstration of the fundamentals of practical dosimetry. Several measuring instruments, which, according to our experience, are reliable, will be shown and their use in the laboratory explained. Without advising the purchase of a particular instrument, we trust to furnish the radiologist with sufficient data to permit him to make his own choice.

ERNST A. POHLE, M.D., PH.D.

# THE DEVELOPMENT OF DOSIMETRY[1]

## AN HISTORICAL SKETCH

By EGON LORENZ, PH.D., Harvard University, CAMBRIDGE, MASSACHUSETTS

IN presenting before you a sketch on the history of dosage, I must at once ask your indulgence for two things: first, it is impossible to give in a short time even an approximately complete account of all the work that has been published, as it has appeared in thousands of papers printed all over the world within the last thirty years, and second, I am afraid that the story of roentgen-ray dosage lacks the dramatic and vivid moments that distinguish the development of roentgen-ray therapy itself: in other words, I fear my speech will be rather tedious.

Only one year after their discovery, the application of roentgen rays for therapeutic purposes was initiated, when Freund used their depilatory action for treatment. However, we must consider Nicholas Senn as the father of roentgen therapy—deep therapy. It was in 1902 that he reported the successful treatment of leukemia with the new radiation, about the same time that the dosage of roentgen radiation for medical purposes originated.

However, before I begin with the historical development of dosage, let me give you a brief account of its definitions and aims.

As is known, we must consider roentgen rays as a medicament which we have to administer like any pharmacological medicament. We must control our dose to prevent injury, to obtain the best results, and to be able to compare the reactions with those obtained by others. But whilst in pharmacology we are dealing with matter the dosage of which is simple and easy, in the case of X-rays we have to deal with the dosage of radiation.

Whenever radiation travels through matter, part of it is being absorbed and this absorbed energy will produce the biological effect. Starting with this, we may define as "physical dose" the amount of radiation or energy absorbed per unit volume, as we have reason to assume that the physical dose is independent of the total energy absorbed in the irradiated tissue. But, although this absorbed energy produces directly the effect in therapy, we can not use it as a measure of dosage since it is impossible to determine in any way how much energy is actually absorbed by a given volume of tissue. Only one fact should be noted: although we know that roentgen radiation on its path through matter is scattered repeatedly, and its quality is altered by the absorption process, we do not know enough about these processes. Further, direct measurements of the energy of roentgen radiation are too delicate to provide a practical method of dosage for everyday use.

Therefore, we are forced to employ as a means of estimating the energy or intensity —which is energy per second—of the beam, some other effect produced by the beam. Any physical reaction that depends uniquely upon intensity will do for practical purposes. Furthermore, as we are accustomed to use the skin as a biological test object we shall measure the surface energy or intensity per square unit by using any physical reaction characterized above.

As the amount of energy absorbed by the tissues depends upon the wave length, and as none of the physical reactions used for dosage purposes can give readings parallel to this absorbed energy, depending as they do upon the amount of radiant energy absorbed by other matter than tissue, we have also to define the quality of our beam by a suitable factor. We, further, have to know

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

the quality to be able to estimate the effect in the depth of the irradiated medium and the intensity distribution.

It will be shown in the following how these main points of dosage have been developed chronologically. We begin with the history of quantitative dosage.

The beginning of roentgen-ray therapy was marked by rather chaotic experimenting without physical and technical foundations; it was not even known how to measure the quantity of the radiation. In physics, the first energy measurements were made by Dorn, who measured the energy of the roentgen rays by means of the air thermometer in 1897, then by Rutherford, who measured it with the bolometer in 1900, and others. The first step toward the measurement of the quantity of roentgen rays for therapeutic purposes was taken by Holzknecht, who described in 1902 the first dosimeter—he called it a chromoradiometer—which used the discoloring effect of the rays on a fused mixture of KCl and $Na_2CO_3$ and which was calibrated in arbitrary units. It was followed by the Sabouraud-Noiré tablets consisting of barium-platinum cyanide, likewise discoloring under the influence of roentgen rays, and the Kienböck strips, which used the action of the radiation upon the photographic emulsion. Almost all effects of roentgen radiation were used to develop a method for dosage during that epoch, but it was hardly possible to bring all these different subjective methods into correlation with one another, a problem which grew more and more vital with increasing use of roentgen rays for therapeutic purposes.

The year 1908 marks a turning point: at that time Villard proposed that use might be made of the ionizing effect of roentgen radiation. His unit is that quantity of radiation which sets free in 1 c.c. of air under normal conditions one electrostatic unit. This definition is the base of our present r-unit. But Villard's idea did not meet with approval—it was almost forgotten. This seems strange, as at that time the method of measuring radiation by its ionization effect was already very well developed in physical laboratories.

Not until 1910 was Villard's idea taken up again by Szillard, who changed Villard's unit—although not fundamentally—by introducing the mega-mega-ion $= 10^{12}$ ions instead of the electrostatic unit. Szillard, further, described the first small ionization chamber, which contained 1 c.c. of air and into which the rays entered through a thin aluminum window. This instrument is the prototype of all the later small ionization chambers. Although Szillard was right in his fundamental idea, his small chamber did not reproduce his unit at all, because the ionization in it was mainly produced by secondary radiation from the walls.

This error was recognized and avoided by Duane. At the Cleveland meeting of the American Roentgen Ray Society, in 1914, he described his unit and the methods for measuring and reproducing it. A more detailed report of his method and his work was given in 1922 and again in 1923. Duane's unit, called E, is given by that quantity of roentgen rays producing in air an ionization current of one electrostatic unit per second. This unit is one of effective intensity, as we may call it, in opposition to Villard's, which is one of effective energy. It was established with a large ionization chamber of such dimensions that practically no secondary radiation struck the walls of the chamber. As early as 1905 Duane had pointed out the importance of the secondary radiation for measuring ionization. For practical use, this E unit was transferred to a small ionization chamber, which, according to Duane, must consist of material of low atomic number to reduce the effects of secondary rays. He used as conductors in these small chambers, thin aluminium sheets or sheets of paper with pencil marks across them. The ionization currents of

both the small chamber and the standard chamber were measured by a galvanometer and checked against a standard cell.

Duane's method of establishing the unit in a large chamber and transferring it for practical use to a small chamber, the constancy of which is controlled, satisfies all the conditions we must demand to-day of a reliable method of physical dosage. As a matter of fact, little fundamental progress has been made in dosage since that time.

Not before 1918 was further work in standard dosage carried out. In this year Friedrich and Kroenig, independent of Duane, published their elaborate studies on the small ionization chamber and the standard chamber. Their unit, based upon Villard's, was the "e" unit. Friedrich especially emphasized that it is essential for the absolute measurement of ionization that wall effects be avoided, and that the complete utilization of the secondary radiation shall be realized. Accordingly, he constructed a large chamber and transferred his unit to a small thimble-shaped chamber of horn, which gave, to a certain degree, readings somewhat parallel to those of the large chamber. But, according to Holthusen, who calculated the range of the secondary radiation produced by the primary roentgen-ray beam and constructed a large chamber according to these calculations, Friedrich's standard chamber was too small for very hard roentgen rays, and therefore did not measure the complete ionization produced by the secondary rays. This induced Friedrich and Glasser, in 1922, to establish the e-unit anew with a still larger standard chamber, and it led finally to the construction of a chamber with high air pressure (about 100 atm.) by Berg, Schwerdtfeger, Thaller, and Behnken, in 1924. However, we can say to-day that Friedrich's first chamber did fulfill the conditions demanded for it. We know that on account of the Compton effect the ionization in air for very hard roentgen rays is produced mainly by the recoil electrons, whose range is much shorter than that of the photo-electrons, and consequently, Holthusen's calculations are not valid. From this point of view the construction of the chamber with high air pressure seems to be an unnecessary complication for establishing a standard.

Behnken's unit, which he called R, is identical with Villard's and Friedrich's. To define conditions more accurately it was added that the secondary radiation must be fully utilized and wall effects avoided. This unit was accepted by the German Roentgen Ray Society. The chamber was set up in the Bureau of Standards in Berlin and used for calibrating small chambers.

In the meantime another unit had been established in France by Solomon in 1921. It is based on a comparison of the ionization produced in air by roentgen rays and $\gamma$ rays. The constancy of the radiation emitted from radium is the basis of this unit. The use of radium for the establishment of a unit had been previously proposed, in 1915, by Winaver and Sachs, but had not been carried out. Solomon called his unit "R" and defined it as "the intensity of a roentgen radiation producing the same ionization per second as one gram of radium placed 2 cm. from the ionization chamber and filtered by 0.5 mm. of platinum." Omitting the discussion of the physical incorrectness of the unit thus defined and the difficulties of carrying it out exactly, its great advantage lies in its simplicity and the facility of reproducing it. Its main disadvantage is its dependence upon the construction of the ionization chamber.

Now, in 1924 several well established units were available and at about that time calibrations of small ionization chambers in units for practical purposes were begun. With such calibrated instruments the radiologist was now enabled to link the quantity of roentgen radiation with the biological effect, for instance, with the erythema of the skin. This is the problem in which the

roentgenologist is interested above all. Such determinations had already been made by Friedrich, Duane, Glasser, Grebe and Martius, and many others; but now, owing to a more general use of instruments calibrated in units, great discrepancies appeared between the different biological doses expressed in physical units. This was due to several causes.

First, it is not possible to measure the biological dose exactly, as it is dependent upon many biological factors. Second, the quality of the radiation employed was not determined uniquely, and it cannot be expected, as already pointed out, that ionization effect in air and biological effect in tissue run parallel for different qualities. Third, the ratio of the readings of the small ionization chambers to those of the standard chamber changed for the chambers employed at that time with the quality of the beam to a considerable degree, and, finally, the construction of the small chamber itself caused faulty measurements. For the purpose of our subject it is sufficient if we consider only the last two points.

Already Duane, Friedrich, and Friedrich and Glasser had pointed out that it is essential that the wall of the small chamber shall be of material of low atomic number in order to eliminate the wall effect. Their small chambers fulfilled this condition for a more or less wide range of wave lengths. In 1924 Fricke and Glasser succeeded in constructing a small chamber whose walls had the same absorption coefficient as air; therefore, the ratio mentioned above was constant for all wave lengths, and in 1925 they established a small standard chamber which gave R-units directly. In the meantime other investigators had pointed out the influence of different effects of the small chamber which cause erroneous readings, as, for instance, the electrode effect, the effect of the position of the chamber, etc., and had shown how to avoid them. Further, more stress was laid upon proper control of the instruments by checking their readings with the $\gamma$ radiation of radium or high ohmic resistances. Finally, in 1927, Glasser constructed a chamber, independent of all these effects, which fulfilled the requirements of an ideal chamber. Owing to this knowledge it was now possible to carry out comparisons of biological doses expressed in roentgen units at different places with more success. As a matter of fact, one succeeded in giving an average value for the quantity of roentgen rays in r-units needed for producing an average erythema dose. Further, the establishment of the unit was repeated at different places and showed good agreement in different countries. The next step was to establish an international unit, and the First International Congress, of 1925, in London, proposed to appoint standardization committees in the different countries, which were to report at the next Congress.

All this work seemed to be in vain as Glasser and Meyer reported in 1926 that they had failed in transferring the r-unit, as established by Behnken, to the United States. They found Behnken's unit about 50 per cent larger than their own, while the latter was in good agreement with the different ionization units established in the United States. On account of the importance of this matter, Behnken came to America in 1927 with a specially constructed small chamber to repeat the comparison of the units. He succeeded in showing that the units agreed within the experimental error. The discrepancies were probably due to faulty construction and lack of proper control of the instruments used in Glasser and Meyer's investigation. The reliability of the electrostatic unit was further proved in 1927 in Duane's laboratory by a re-establishment of Duane's unit with a new chamber, the readings of which agreed within 0.7 per cent with those of the old standard, and by Behnken, as well as Glasser, by comparing their unit with Solomon's R-unit. Both found the same proportionality constant.

Thus the electrostatic unit was sufficiently well established so that the Second International Congress, in Stockholm, in 1928, could adopt it as the International Unit, with the following definition: "The unit is the quantity of X-radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 c.c. of atmospheric air at 0° C. and 76 cm. mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current."

Now let us go back again to the early beginnings of therapy with roentgen rays. We have already explained that the measurement of the quantity of radiation is not sufficient to define the radiation uniquely. We need, in addition, a statement as to its quality. Further, we need some knowledge about the intensity distribution, because it is our aim in deep therapy to influence diseased cells lying beneath the surface of the skin.

Probably the first to emphasize the importance of the quality of roentgen radiation used for therapeutic purposes were Sträter and Kienböck, in 1900. Fundamental progress in this direction was made by Perthes, in 1904, and especially by Dessauer, in 1905. Perthes investigated for the first time the intensities of the roentgen rays within the human body, finding that the decrease in intensity is less with hard tubes. His chief contribution was the introduction of a filter to obtain only the penetrating components of the beam for therapeutic purposes. Dessauer's work, which was more systematic and carried out independently of Perthes, led to the establishment of his conditions of the qualitative and quantitative homogeneity of the radiation. We mention here only two conditions: the first demands that the quality of the beam must be practically the same for the total irradiated area, obtained by the use of the proper filter; the second demands that the quantity of the radiation must be practically homogeneous in the diseased area. The fundamental importance of these conditions, although doubted very often, has been re-established at the present time.

To determine the quality, the roentgenologist of that time used different methods, a few only of which I shall name: the different meters for hardness (by Benoist, Wehnelt and Walter) and the spark gap (introduced by Béclère). These methods were mostly subjective and inaccurate, as were the methods of that time for measuring quantity.

The first objective and accurate method for measuring the quality of a beam was introduced by Christen in 1912. He measured the thickness of a filter of suitable material necessary to reduce the intensity of the beam to 50 per cent, calling it the half value layer. Duane, in 1914, determined the quality of the beam by introducing the effective wave length, which is the wave length of the monochromatic beam of rays for which the reading of the measuring instrument would be reduced in the same ratio as for the actual beam when the sheet of absorbing material is placed in the path of the rays. The reliability of the lambda effective was proved, for instance, by Hickey and Pohle in 1928.

Dessauer and his co-workers, in 1914 and later, used the absorption coefficient of aluminium and water for determining the quality, a magnitude which measures the ratio of absorption in layers of equal thickness. They also pointed out the importance of determining the quality more exactly by adding a statement about the voltage applied to the tube. It is doubtful whether as much information in regard to the quality of a beam of roentgen rays can be obtained by means of two measurements in any other way as by determining the effective wave length. The determination of the half value layer and the absorption coefficient requires a series of measurements. Furthermore, the half value layer has no simple physical meaning. However, a complete analysis of the radiation is

obtained only by the use of a spectrometer, but this is too complicated for the present discussion.

Concerning the determination of the quality, the following was proposed by the International Congress in Stockholm: "The quality of roentgen radiation used for practical purposes is very varied and it would be impracticable to give a complete specification of it, but much information can be obtained from a knowledge of the degree of absorption in standard materials, the peak voltage applied to the tube, together with the filter employed and the general character of the high tension apparatus. For practical purposes the quality may be expressed by stating the half value layer in a suitable material or by stating the effective wave length as determined by the percentage amount of radiation transmitted through a given thickness of a suitable material (Cu. or Al.)."

It remains to make a few historical remarks on the problem of the intensity distribution within the human body. Christen, in 1912, tried to compute the intensity distribution from the inverse square law and the absorption laws; others tried to measure it with the so-called aluminium phantom and the Kienböck dosimeter. These attempts met with no success. The importance of the scattered radiation was not known at that time. Barkla, in 1913, was the first who pointed out the importance of this factor, the correctness of his statement being proven by Friedrich and Kroenig in 1918. By measuring the intensity distribution within and outside of the beam with their small ionization chamber, they could show the extraordinary effect of the scattered radiation. However, the most complete and exhaustive work on this subject was done by Dessauer and Vierheller in 1921, the material gained by these investigations being published in the form of isodose charts. Many other investigators in all countries have done considerable work in trying to solve the problem of the intensity distribution, a subject concerning which it is impossible at this time to go into detail. Unfortunately the sucecss of this tremendous amount of work has been small, many of the investigations being based on faulty physical foundations. While many of them show the same principal characteristics, they reveal considerable variations in the absolute values of the intensities in the depth, etc. We must say that we have no measurement of the intensity distribution up to the present that may be used as standard.

In conclusion, I feel inclined to assume that a certain ultimate stage has now been reached in dosage, a stage which will enable the practical roentgenologist to use roentgen radiation with more accuracy, thus improving his technic and consequently his success. However, rapid progress is being made in the methods of roentgen-ray measurements and in our knowledge of roentgen-ray phenomena. For the physicist, therefore, this stage is only provisional, and new knowledge may soon render obsolete what to-day seems to be ultimate.

# ERYTHEMA AND TOLERANCE DOSES IN AMERICAN CLINICS[1]

## A STATISTICAL STUDY

By OTTO GLASSER, PH.D., and U. V. PORTMANN, M.D.,
Cleveland Clinic Foundation, CLEVELAND, OHIO

WHEN the leader of this symposium on dosimetry asked us to make a statistical study of the erythema doses for certain radiation conditions as measured in r-units and in effective wave lengths in various American clinics, we realized that the task of collecting this material at the present time would be a difficult one. We appreciated many of the technical problems and the variations which must be considered in judging the various stages of skin reaction produced by roentgen rays, and also the fact that in some quarters there is uncertainty as to the proper use of the r-unit, so that these factors would prevent us from securing practicable results. However, in order to arrive at some preliminary conclusion, we sent to sixty-five American therapy institutions questionnaires in which the following specific questions were asked:

1. What method do you use to judge the erythema and pigmentation reactions?
2. How often and how many days after radiation do you usually observe these reactions?
3. What type of dosage instrument do you use?
4. Where was it calibrated in r-units?
5. Do you measure the output of your X-ray apparatus in air and then calculate the dose at the site of radiation on the patient, or do you measure the dose directly on the patient during treatment?
6. Do you measure these doses for various conditions of radiation?
7. Can you indicate in r-units between what limits you always obtain an erythema reaction?
8. Can you indicate a dose in r-units which lies just under the lower limit, *i.e.*, which does not cause a skin reaction?
9. Can you indicate doses in r-units which correspond to erythema reactions of the first, the second, and the third degree?

These questions were preceded by the following definition: "The skin unit dose is defined as that dose of roentgen rays which, under certain given technical conditions, causes a slight reddening of the radiated area about a week after radiation. This is followed by a yellow-brownish discoloration about three weeks after radiation, and by a definite browning about six weeks after radiation."

It was gratifying that our letter was answered by sixty-one out of the sixty-five institutions—a proof of the general interest in the question of dosage measurements in radiation therapy. Twenty-one of the responses received contained incomplete information and could not, or did not, answer fully our questions. They were excluded, therefore, from the final analysis. We wish to express our appreciation to all the radiologists who have co-operated with us in the study of these dosage problems.

Some of the answers obtained indicated that our fears had not been entirely unfounded. We were criticized for our attempt to offer a definition of a standard erythema dose similar to that suggested by Wintz, in Erlangen, and by many of his followers. One of the answers read as follows: "This skin unit dose, as you define it, is obsolete, and should be discarded. I do not accept erythema and pigmentation as a standard of or for anything, and I do not check any dose against such an old-fashioned and meaningless reaction; hence, I can not answer your questions. The skin unit dose, as defined above, has prevented us from really getting

[1]Read at the Fifteenth Annual Meeting of the Radiological Society of North America, in Toronto, December 2–6, 1929.

somewhere in the treatment of malignancies."

In another answer a similar statement is made: "The whole erythema unit is just as uncertain as fogs here in New York. I believe the whole erythema business ought to be hung in the closet, and I believe that it, together with the extremely careless definition of radiation quality, is responsible for the very poor results that are reported."

These criticisms of the inaccuracy—or rather the difficulty—of judging therapeutic doses on the basis of skin reactions are well founded, and we certainly subscribe to them from our practical and experimental experience. We have very often spoken of this fallacy. On the other hand, this criticism of the skin unit dose, or the erythema dose, or the tolerance dose, leads us nowhere unless we combine it with the proper suggestions for replacing this method of determining doses by some more accurate standards.

Some of the answers offer a hopeful outlook in this respect. The following statement by a prominent radiologist may be of interest: "It seems to me that it never will be possible to fix absolutely accurate erythema doses for all conditions, and that it always will be wise to check each individual patient, and to radiate well within the safety zone to begin with." A similar statement from an equally prominent radiologist reads: "The erythema we judge simply by the eye. No attempt is made to determine the depth of reddening any more than to say 'faint erythema' or 'deep erythema.' The same is true of pigmentation. Skins vary so much that I think these factors amount to little." Both of these radiologists follow up their remarks by an excellent series of well-determined and reproducible doses in physical and biologic units.

Such suggestions seem to offer a welcome solution to the dose problem. The old-fashioned biologic doses should be replaced by those measured in r-units, followed by quality indications in effective wave lengths, and by a statement of the radiation technic used. However, in adopting the r-unit for general radiation therapy, we must realize its limitations. It is a physical dose unit, and does not take into consideration the many more or less unknown factors which comprise the variations in the individual patient, and which undoubtedly have an important influence on the final total dose. It will always be wise, and also absolutely necessary, to study and to check each patient.

In the future, the roentgenologist who prescribes his physical dose in r-units and in effective wave lengths, and who indicates his radiation technic, basing his prescription upon a careful study of all the factors which determine the total dose, will be speaking a language which can be understood internationally. If this is done in practical work, as well as in the literature, the difficulties presented by the problem of dosage in radiation therapy will be overcome to a great degree. The prediction offered in one of the answers to our questionnaire that the "skin unit dose of ancient days will pass" and is "soon to be forgotten" will be realized.

It was necessary to go to some length in explaining the meaning of therapeutic radiation doses, since our questionnaire had to be written in a simple form in order to start any discussion of the problem. In order to connect up the doses measured in physical units with the existing clinical dose terms, it was thought wise to select a dose definition similar to the one given by Wintz, which has gained wide usage within the past ten years. It was expected that everybody who has had experience with the study of skin reactions would, of course, be familiar with the shortcomings in the practical determination of these doses, and also with the difficulty of studying the various cycles in which an erythema reaction of the skin normally occurs.

The information obtained by the use of the questionnaires can be condensed into

three parts. The first refers to the dosage instruments used and to the standardization laboratory in which they were calibrated in r-units. The second deals with the determination of the average erythema dose in r-units for given conditions of radiation, and with its observation. In the third, we tried to obtain information upon the dependence of r-units per erythema dose upon the radiation quality.

Realizing that the practical use of the r-unit is still in its early stages in this country, and that the accuracy of its value is even questioned by some workers, the questionnaires were sent to those therapy institutions employing dosage instruments which had been calibrated by comparison with the large air chambers of Duane in Boston, Behnken in Berlin, and our own in the Cleveland Clinic, or which were standardized under the supervision of one of these laboratories. Our r-unit was established as the *e*-unit in 1924 (1), and has remained unchanged since then. The satisfactory comparisons of our own standard (2) with Duane's three years ago (November 5, 1926), and with Behnken's (3) two years ago (November, 1927), show that the practical instruments referred to carry the same r-unit within an accuracy of a few per cent. Recently we were invited by Mr. Taylor, of the United States Bureau of Standards, to compare our r-unit with that now established at the Bureau. This comparison was made in November, 1929, in Washington, our unit being transported by means of a condenser dosimeter and a Fricke-Glasser dosimeter. The agreement between the two units was found to be very satisfactory, the difference being only about 2 per cent.

The following types of instruments were employed in the various therapy institutions from which answers to our questionnaire were received: 18 Victoreen X-ray dosimeters, 6 Wulf ionometers, 4 Duane ionization chambers, 3 Siemens dosimeters, 3 Standard Company air chambers, 2 Küstner air chambers, 1 Chamberlain air chamber. Twenty of these instruments were calibrated or recalibrated in the International r-unit in our laboratory or under our supervision; 8 were calibrated in Behnken's laboratory; 6 in Duane's, and 1 in Chamberlain's laboratory.

In regard to the other questions, it was necessary to make a careful analysis of clinical doses measured in r-units, at the same time keeping in mind the difficulty of judging an erythema reaction. It was decided first to select only the data which referred to skin reactions produced with relatively hard rays, such as are used in deep therapy under certain standard conditions, *i.e.*, about 200 K.V., ½ mm. Cu. filter, large area, 50 cm. focal distance, and 0.15 Å. effective wave length. Only those reports which indicated all of these radiation conditions in addition to the number of r-units and the radiation quality, were made use of in our analysis. It was also decided to reduce all of the reported doses to an average erythema dose; that is, one which would produce a visible skin reaction in about 75 per cent of the radiated cases, provided that the full dose is applied in one sitting. Since, in some instances, this had been measured in air and not on the patient, it was necessary to transfer and calculate the dose which would be applied to the patient. For the conditions stated above, we added 40 per cent as an allowance for back-scattering when the doses were measured in air. Most observers examined the treated area visually at various intervals after the treatment. Only three of the radiologists used some kind of an erythema meter with a scale or microscopic examination of the skin, in order to arrive at a closer judgment of the reaction.

We have stated previously that forty (65 per cent) of the sixty-one answers obtained were of practical value in compiling our

data. The results of this compilation are given in Table I.

TABLE I

| Radiation Therapy Clinic | Number r-units for average erythema reaction in deep therapy (ca. 200 K.V., ½ mm. Cu. $\lambda_{eff} = .15$ Å. large area, 50 cm. focal distance). |
|---|---|
| No. 1 | 500 |
| 2 | 560 |
| 3 | 600 |
| 4 | 625 |
| 5 | 625 |
| 6 | 625 |
| 7 | 625 |
| 8 | 775 |
| 9 | 800 |
| 10 | 800 |
| 11 | 800 |
| 12 | 840 |
| 13 | 840 |
| 14 | 850 |
| 15 | 850 |
| 16 | 875 |
| 17 | 900 |
| 18 | 900 |
| 19 | 900 |
| 20 | 900 |
| 21 | 910 |
| 22 | 920 |
| 23 | 975 |
| 24 | 1000 |
| 25 | 1050 |
| 26 | 1050 |
| 27 | 1050 |
| 28 | 1050 |
| 29 | 1100 |
| 30 | 1100 |
| 31 | 1100 |
| 32 | 1100 |
| 33 | 1120 |
| 34 | 1125 |
| 35 | 1200 |
| 36 | 1200 |
| 37 | 1200 |
| 38 | 1200 |
| 39 | 1200 |
| 40 | 1250 |

Average number of r-units per erythema at 40 therapy clinics, 930 r-units.

A rather large range of the number of r-units per erythema dose must be expected, according to the reasoning given above. The same reasoning permits of condensing these various doses to an average for an erythema dose, which is found to be 930 r-units. The same dose without back-scattering, that is, measured in air instead of on the patient, would amount to 660 r-units. At the present time we shall refrain from going into a discussion of these values, but it is of interest to mention that a dose of 550 r-units (in air) as an equivalent for an average erythema dose was found by Küstner two years ago, as the result of a questionnaire similar to ours which was sent to a number of German clinics. In answering questions No. 8 and No. 9 regarding minimum erythema doses, tolerance doses, etc., a few of the radiologists sent valuable information and made helpful suggestions. The number of these answers, however, is much too small to permit us to make use of them in the present study of the question, but it is of interest to state that some radiologists have regularly produced visible reactions with 250 r-units on small areas, while others go as high as 4,000 r-units given to one area in the course of only one week.

A few more answers, twelve out of sixty-five, were obtained on questions No. 6 and No. 7 which refer indirectly to the quality effect of radiation upon erythema doses in r-units. The factors involved in this part of the study were increased by the difficulty of determining accurately the quality. We have mentioned that the prescription of the physical dose must contain the radiation quality in effective wave length, and that the importance of this limitation must not be underestimated. Three of the twelve who replied to this question doubted whether the erythema dose measured in r-units depends in any way upon the radiation quality, while the rest—nine out of twelve—questioned the definite existence of such an effect. The small number of answers, however, suggested the fact that this special part of the problem also needs further study before definite conclusions can be drawn.

In conclusion, the fact has been brought out that the study of the answers obtained in sixty-five questionnaires sent to American therapy institutions in an attempt to obtain information on the correlation of the data relative to the erythema dose on the human skin as measured in r-units, permits us to draw some valuable conclusions:

1. Such terms as "erythema dose," "skin

unit dose," "tolerance dose," etc., can and should be replaced by the much more accurate indication of dose in r-units and in effective wave lengths, together with a statement of the radiation conditions involved. A careful study of each individual patient and of the various other factors that also influence the total effective dose should always be made.

2. An average erythema dose, according to the present use in deep therapy, for specified radiation conditions, corresponds to about 930 r-units if measured on the patient, and about 660 r-units if measured in the air.

3. The question as to the number of r-units equivalent to other clinical doses, such as the minimum erythema dose or tolerance dose, and also the question as to the influence of quality upon the number of r-units per erythema, still remain unanswered.

## REFERENCES

(1) GLASSER, OTTO: Calibration of Friedrich's Iontoquantimeter. Fort., a. d. Geb. d. Röntgenstr., 1924, XXXII, 343.

(2) GLASSER, OTTO, and MEYER, W. H.: Erythema Doses in Roentgen Units (IV). Strahlentherapie, 1927, XXIV, 710.

(3) BEHNKEN, H.: The Problem of the Roentgen Dose Unit. Strahlentherapie, 1928, XXIX, 192.

# STUDIES OF THE ROENTGEN ERYTHEMA OF THE HUMAN SKIN[1]

## III. MACROSCOPIC AND SKIN CAPILLARY CHANGES AFTER COMBINED EXPOSURE TO ROENTGEN RAYS AND ULTRA-VIOLET RAYS

By ERNST A. POHLE, M.D., PH.D., F.A.C.R., Professor of Radiology, and CECIL S. WRIGHT, B.S., M.D., Senior Resident in Radiology, University of Wisconsin Medical School, MADISON, WISCONSIN

ROENTGEN rays and ultra-violet rays belong to the same electromagnetic spectrum; they differ considerably, however, in the wave length; both produce a reddening of the human skin if applied in sufficient quantity. While the reaction following ultra-violet exposure usually disappears within a short time, the roentgen reaction appears in several cycles extending over weeks and months. In every case, the skin capillaries show typical changes (1, 2). They consist essentially in a marked dilatation, with an appearance of the subpapillary layer and of the so-called reserve capillaries. From this, it would be logical to expect that the two radiations combined might enhance the skin reaction. Nevertheless, a thorough course of ultra-violet exposures has been recommended before the administration of roentgen rays, with the claim that a higher dose of roentgen rays may safely be given (3). This statement has not remained unchallenged (4, 5); so far as we know, very few have followed the procedure outlined above. On the other hand, a number of cases showing skin injuries following exposure by roentgen rays have been improved by conservative treatment with ultra-violet rays (6). We have had similar experiences where small but painful ulcers in atrophic and indurated skin due to X-ray exposure cleared up following exposure to radiation of an air-cooled quartz mercury vapor lamp; the telangiectasis remained unchanged. While we fully realize the difference between these two cases, the mechanism of the effect of ultra-violet rays is difficult to explain. In view of the practical importance of the problem, we decided, therefore, to study, on a systematic basis, the combined effect of roentgen and ultra-violet rays on the skin.

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929, as a part of a Symposium on Dosimetry.

### EXPERIMENTAL WORK

Although there is no doubt but that human skin represents the most desirable test object, one must realize that it is not always safe to carry out this type of research on human skin. The long periods of observation necessary in this work do not render the task easy. While a limited number of tests were performed with utmost caution on human skin, the majority of experiments was conducted on animals. Healthy adult white rats of the same strain which had been used successfully before for similar studies (7) proved to be adapted to our purposes.

The roentgen exposures were carried out with valve type apparatus and air-cooled Coolidge tubes; for potentials over 100 K.V., a Müller tube was used; an air-cooled quartz mercury vapor lamp served as source of ultra-violet radiation. The output of the X-ray apparatus was calibrated in r-units by two ionization instruments with small chambers, which had been checked against the open air ionization chamber of Duane, in connection with a galvanometer and standard cell. Table I gives the quality and quantity of the radiation as obtained in these measurements. The emission of the quartz mercury vapor lamp was controlled by a cadmium photo-electric cell

calibrated according to the method developed by Pohle and Sawyer (8). The doses refer to the ultra-violet unit corresponding to an average erythema on normal adult human skin. An exposure of 5 to 6 U.V.U. produced a faint reaction, which might be called threshold erythema for rat skin. The irradiation of all rats was carried out with one quality of roentgen rays, produced at 60 K.V., without filter. A series of preliminary tests led us to study closely the following combination of exposures.[2]

*Group I.*—Three fields were treated: the upper field received 2,400 r, the center field received 1,200 r + 2.5 U.V.U., the lower field received 5 U.V.U. (Code: B.)

Four to five days following the exposure, the lower and middle fields were definitely outlined, with a slight preponderance of the middle area.

On the tenth day, the outline of the upper field appeared, while the middle field showed desquamation, and the lower, a slight tanning.

Fourteen days following the exposure, the upper field developed the typical ulceration; the middle field began to show regression, while the lower appeared faintly tanned (Fig. 1, B 14).

Thirty days following the exposure, the upper field was completely epilated, showed crusting in spots and considerable desquamation; the middle field had healed with a smooth scar. The lower area was still pigmented, and the hair began to grow (Fig. 1, B 30).

Two months following the exposure, the upper field was in a state of regression but still showed desquamation in spots; the center area remained healed, while the lower field presented no definite change.

Three months after the treatment, the upper field had completely healed, with a whitish, epilated scar; the middle field was pigmented, with fine hair growing in spots on the area; the lower field was pigmented, and the hair regrowing (Fig. 1, B 90).

*Group II.*—Twenty-four hundred r were applied to two areas; the lower field received, in addition to that, 5 U.V.U. immediately after the X-ray exposure. (Code: C.)

The lower field became visible first about the seventh day; on the fourteenth day, both areas showed marked reaction, more definitely on the lower field (Fig. 2, C 14). After one month, the lower field was healing well, while the upper was still covered by crusts (Fig. 2, C 30). Two months after the treatment, both fields presented a smooth, whitish, epilated scar; neither field showed regrowth of hair (Fig. 2, C 60). Three months following the exposure, there was no essential change as compared with the appearance of the areas one month previously.[3]

[2] In each group there were three animals treated alike; most groups were repeated at least once. Including the preliminary work, a total of sixty-two animals was used.

[3] While slides of all groups were shown at the meeting at which this paper was read, only a limited number of selected photographs are printed, in order to avoid an excessive number of cuts.

TABLE I

| K.V. | Ma. | Filter | λ eff. in A. U. | F.S.D. | r/sec. |
|---|---|---|---|---|---|
| 60 | 5 | 0. | .58 (2.0 Al.)* | 30 cm. | .62 |
| 140 | 4 | 1.0 Al. | .34 (4.0 Al.) | 50 cm. | .5 |
| 140 | 4 | .25 Cu. + 1.0 Al. | .19 (1.0 Cu.) | 50 cm. | .14 |

*This indicates the transmitting material and identifies the Duane chart used in computing the effective wave length

*Group III.*—The procedure as outlined in Group II was repeated but only 1,000 r were given. This dose produced a just visible reaction, without ulceration. (Code: D.)

Eight days following the exposure, the outline of the lower field was faintly visible, while the upper field did not show any macroscopical reaction; on the thirteenth day, the lower field was definitely outlined and the upper area became just visible. Within a month, the hair on both fields began to regrow. There was more pigmentation on the lower field, which remained visible even after three months (Fig. 3, D 90).

*Group IV.*—Exposure of two fields with 2,400 r produced an ulceration within thirteen to fifteen days. After the appearance of the ulcers, the lower field received a single dose of 5 U.V.U. (Code: E.)

The ultra-violet radiation was applied in order to study its effect on the healing process. For the next ten to fifteen days, the regression of the lower area seemed considerably delayed (Fig. 4, E 30), but after two months and three months, respectively, the areas showed no marked difference (Fig. 4, E 90).

*Group V.*—The ulcers were produced in the same manner as in Group IV. The upper field then received three to five exposures of ultra-violet radiation on three to five successive days, one U.V.U. each time. (Code: F.)

In this group, the ulcers were fully developed sixteen days following the exposure (Fig. 5, F 16). Thirty days after the X-ray exposure, or approximately ten days after the last ultra-violet exposure, the upper field still showed crusts in several spots, while the lower field had almost healed (Fig. 5, F 30). One month later, however, both areas presented a smooth scar. The epithelium was perhaps slightly thinner in the lower field (Fig. 5, F 60). Three months after the X-ray exposure, both areas had healed, with a whitish, epilated scar.

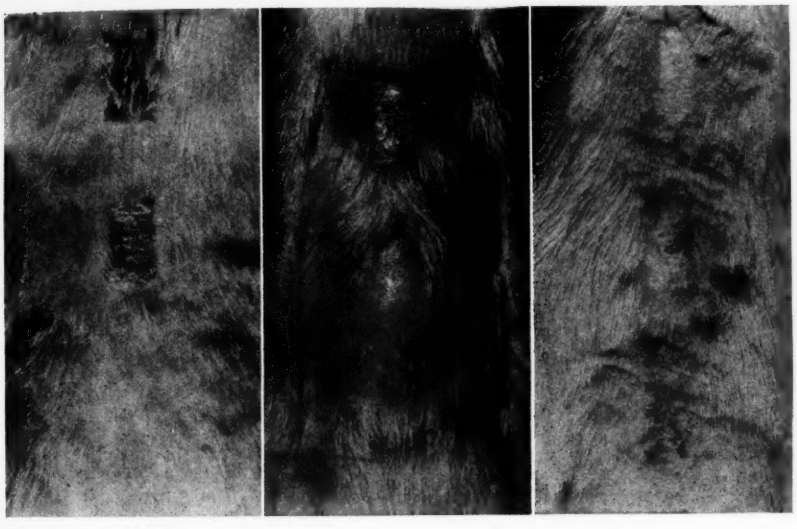


Fig. 1. Upper field, 2,400 r; center, 1,200 r + 2.5 U.V.U.; lower field, 5 U.V.U. B 14, two weeks after exposure; B 30, one month after exposure; B 90, three months after exposure.

No characteristic differences could be detected between the two fields (Fig. 5, F 90).

*Group VI.*—The upper field received 10 U.V.U. daily on three successive days, then

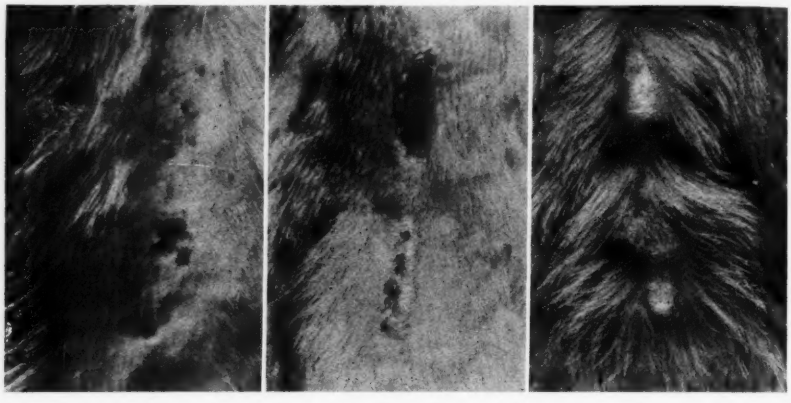


Fig. 2. Upper field, 2,400 r; lower field, 2,400 r + 5 U.V.U. simultaneously. C 14, two weeks after exposure; C 30, one month after exposure; C 60, two months after exposure.

both upper and lower fields 2,400 r each. (Code: G.)

On the third day, the upper field was well outlined showing definite ultra-violet reaction (Fig. 5, G 3). Three days after the X-ray exposure, the upper area had already begun developing an ulcer, while the lower field was not visible (Fig. 6, G 7). Ten days after the X-ray exposure, the outlines of the lower area just appeared. Nine days later, the ulcer on the lower field had fully developed. The upper area, however, had started to undergo regression (Fig. 6, G 23). One month after the first ultra-violet exposure, or twenty-six days after the X-ray exposure, the lower field was still partly ulcerated and covered with crusts, while the upper field had healed entirely (Fig. 6, G 30). Two months following the first ultra-violet exposure, both areas presented white, epilated scars, the epithelial layer being slightly thinner in the upper field (Fig. 6, G 60). One month later, no changes could be noticed as compared with the conditions existing at the two-month period.

The tests on human skin were carried out with three different types of radiation (see Table I), on four to six adults[4] in each group.

*Group A.*—Unfiltered roentgen rays produced at 60 K.V., exposure of two fields of 2 cm. × 2 cm. each, on the flexor side of the right forearm and of three fields of the same size on the flexor side of the left forearm. The upper area on the right arm received 300 r, the lower area 300 r plus 1 U.V.U.; on the left arm, the upper area received 1 U.V.U., the middle area ½ U.V.U. plus 150 r, and the lower area 300 r. Reactions were readily visible on all fields six to ten hours after the exposure (Fig. 7, A 8 H). The three fields on the left arm presented approximately the same degree of reddening, while on the right arm there was a definite preponderance of the lower area. The capillary microscope revealed the characteristic changes of the roentgen and light erythema. Dilatation of the small blood

[4]The majority of these individuals were healthy adults, members of our staff who volunteered to have these tests carried out upon their persons.

vessels was most marked in the lower area of the right arm. Within twenty-four hours the reaction started to subside, and the upper area on the left arm appeared could barely be recognized, and the capillaries had returned to the normal state.

*Group B.*—Roentgen rays filtered through one millimeter aluminum produced at 140

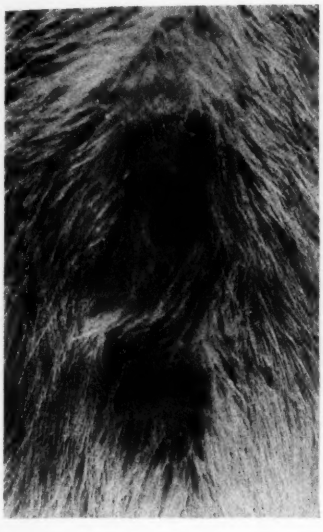


Fig. 3. Upper field, 1,000 r; lower field, 1,000 r + 5 U.V.U. D 90, three months after exposure.

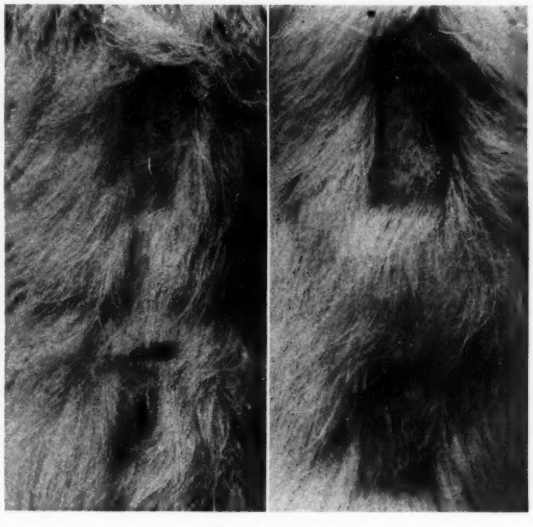


Fig. 4. Upper field, 2,400 r; lower field, 2,400 r and additional 5 U.V.U. after appearance of X-ray ulcer. E 30, one month after exposure; E 90, three months after exposure.

slightly pigmented. On the fourteenth day, the left upper area had almost disappeared, while the remaining fields on both arms presented nearly identical reactions. The center area on the left arm and the lower area on the right arm had a red-brown color, apparently due to early pigmentation following ultra-violet exposure (Fig. 7, A 14). After thirty days, the outlines of the upper field on the left arm could be seen only after inducing hyperemia. The other fields on both arms were pigmented, with a preponderance of the lower field of the left arm and both areas on the right arm (Fig. 7, A 30). Two months after the exposure, all fields except the upper area on the left arm were still faintly visible. Three months following irradiation, the outlines of all areas

K.V. Arrangement of the fields the same as in Group A.

The reaction on all fields took essentially the same course as in Group A. It is particularly noteworthy that there was no measurable difference in the degree of erythema in the fields which received 300 r only as compared with those in Group A.

*Group C.*—Roentgen rays filtered through 0.25 Cu. + 1.0 Al. produced at 140 K.V. Arrangement of the fields the same as in Group A.

Five to ten hours following the exposure, all fields showed definite reactions, most pronounced in the lower area of the right arm (Fig. 8, C 8 H). On the fourteenth day, there was but a faint degree of erythema in the lower area of the left arm and

both areas on the right arm. The reaction in the fields exposed to 300 r only was less than in the respective fields of Groups A and B. The upper and center fields on the left arm and the lower field on the right arm ing period were considerably hastened. On the thirtieth day, the upper area was still covered by crusts while the lower area had partly healed. However, after two and three months, the fields looked more or less

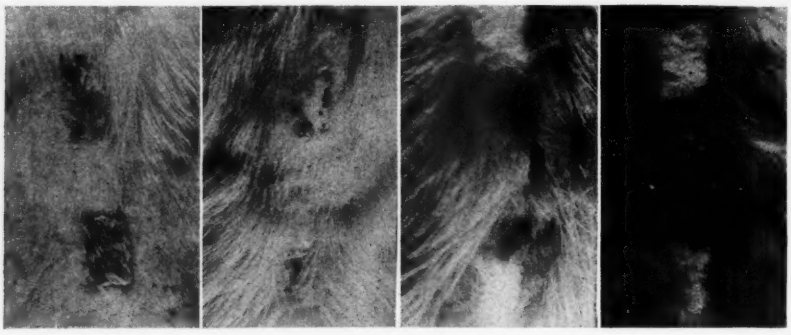


Fig. 5. Upper field, 2,400 r; lower field, 2,400 r and additional 1 U.V.U. each on three to five successive days after appearance of ulcer. F 16, 16 days after exposure; F 30, one month after exposure; F 60, two months after exposure; F 90, three months after exposure.

appeared pigmented in spots. After one month, all fields except the upper area on the left arm showed definite pigmentation (Fig. 8, C 30). After two months, the fields on both arms were fading, and after three months, they were barely visible. At that time, the capillaries did not reveal any marked deviation from the normal.

## DISCUSSION OF RESULTS

The first five groups of animals showed a definite enhancing effect of the ultra-violet rays on the X-ray reaction. In Group I, the upper field (2,400 r) had a longer latent time as compared with the center area (1,200 r + 2.5 U.V.U.) and remained epilated. This means that the biological action of the ultra-violet dose was not equivalent to that of 1,200 r. If 2,400 r were given and combined with a single dose of 5 U.V.U. at the time of the X-ray exposure (Group II), the appearance of the reaction and the healalike, which speaks for a temporary influence of the ultra-violet radiation. Lowering the X-ray dose to 1,000 r (Group III) did not bring out as well this accelerating effect of the ultra-violet rays. Acute X-ray ulcers (Groups IV and V) were not benefited by ultra-violet exposure whether in a single dose or in three to five fractional doses. On the contrary, the regression appeared delayed, although, as in the previous groups, this effect was overcome by the fifth to sixth week. The observations made in Group VI were similar to those in the second group. It is obvious that the three ultra-violet exposures administered on three successive days produced a marked erythema and slight scaling of the skin. Here again, the X-ray effect was aggravated even more than in any other group, since the area which had received the combined exposure displayed a violent reaction as early as the third day after roentgen irradiation. Usually, the ulcers did not appear before

from fourteen to twenty days. The lower area (2,400 r only) developed the ulcer between the seventeenth and nineteenth day, while the upper field had already started healing. On the thirtieth day, the upper field had completely healed but the lower area was still ulcerated. Inasmuch as this same observation was repeated in a total of twelve animals, we must conclude that the preceding ultra-violet exposure hastened the appearance of the roentgen reaction but that it also shortened materially the healing process. The X-ray area had a longer latent time but also healed more slowly. After from two to three months, both fields presented almost identical scars. From a practical standpoint, we can not see, therefore, a great value in this procedure, assuming, of course, that human skin would act the same. The quicker healing time is counterbalanced by the more violent reaction and the resulting scars are obviously the same. Since some of the animals have been under observation for as much as one year following the exposure, we can state that during this period both areas have remained healed.

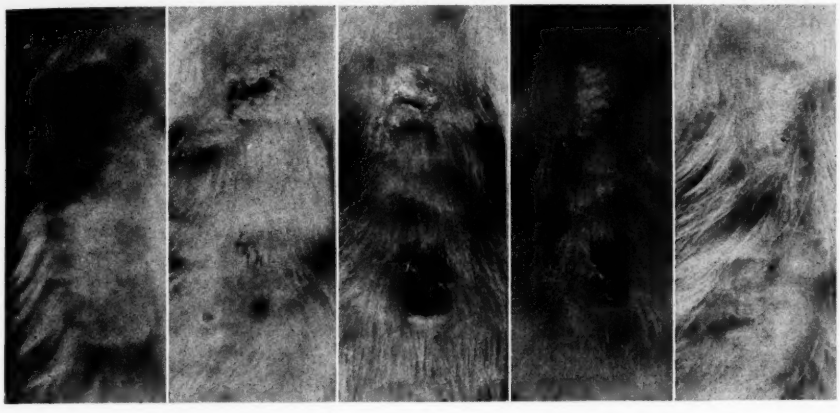


Fig. 6. Upper field, 10 U.V.U. each on three successive days, then 2,400 r; lower field, 2,400 r only. G 3, after last ultra-violet exposure; G 7, three days after X-ray exposure; G 23, 19 days after X-ray exposure; G 30, 26 days after X-ray exposure; G 60, 56 days after X-ray exposure.

The tests on human skin were limited by an obligation to avoid permanent pigmentation. As a whole, they support the observations made in rats, *i.e.*, there seems to exist

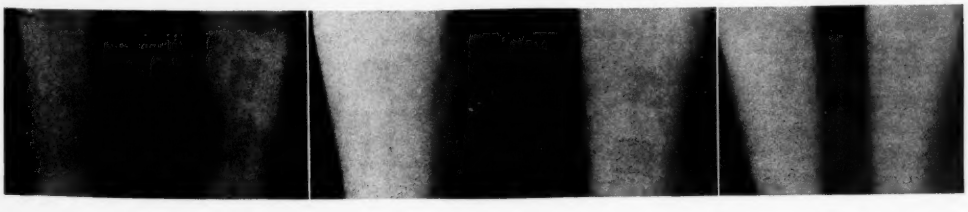


Fig. 7. Right arm: upper field, 300 r; lower field, 300 r + 1 U.V.U. Left arm: upper field, 1 U.V.U.; center, 0.5 U.V.U. + 150 r; lower field, 300 r (60 K.V., no filter). A 8 H, eight hours after exposure; A 14, two weeks after exposure; A 30, one month after exposure.

a definite increase in the reaction if roentgen irradiation is combined with ultra-violet exposure.[5] The left center area (150 r + 0.5 U.V.U.) showed approximately the same degree of reddening as the left upper field (300 r only).[6] This is in contrast to the corresponding animal experiments, but may be due to the difference in dosage. The pigmentation appearing in the left center area and in the right lower field was undoubtedly caused by the ultra-violet component of the radiation. That this could not be seen as characteristically in rats can perhaps be explained by the difference in the susceptibility of the two types of skin. The wave length of roentgen rays had no apparent effect on these findings. One observation reported by Glocker, Hayer, and Jüngling (9) could be confirmed. While the areas exposed to 300 r at 60 K.V. (no filter) and at 140 K.V. (1.0 Al.) developed an identical degree of erythema, the field irradiated with the same dose of roentgen rays at 140 K.V. (0.25 Cu. + 1.0 Al.), *i.e.*, with a shorter wave length, showed less reaction. It seems, then, that, for small doses, the longer wave length is more effective biologically when using the skin as test object. At higher doses, this difference disappears almost entirely (10).

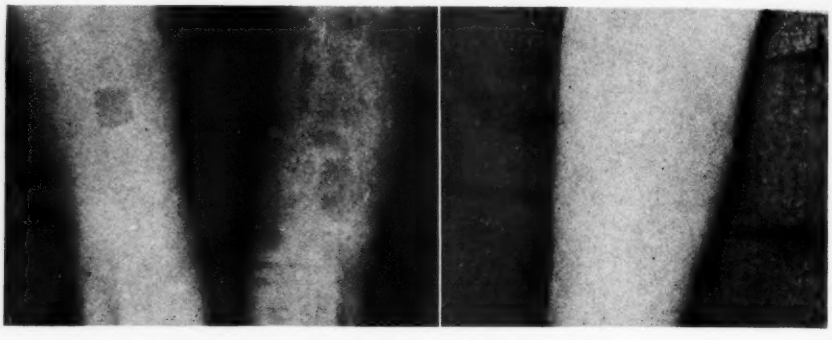


Fig. 8. Right arm: upper field, 300 r; lower field, 300 r + 1 U.V.U. Left arm: upper field, 1 U.V.U.; center, 0.5 U.V.U. + 150 r; lower field, 300 r (140 K.V., 0.25 Cu. + 1.0 Al.). C 8 H, eight hours after exposure; C 30, one month after exposure (right arm only).

[5] See also: Halberstaedter, L., and Simons, A., *Strahlentherapie*, 1923, XV, 65.

[6] No attempt has been made to express mathematically the relation between the degree of erythema in a field irradiated by roentgen plus ultra-violet rays and the sum total of the degrees of erythema in the two fields irradiated by each component radiation.

SUMMARY

1. The combined effect of roentgen rays and ultra-violet rays was studied on the skin of rats and on human skin. Three qualities of roentgen rays were used; an air-cooled quartz mercury vapor lamp served as source for the ultra-violet radiation. The X-ray doses are expressed in r-units; the output of the ultra-violet lamp was controlled by a calibrated photo-electric cell.

2. All experiments led to the conclusion that ultra-violet radiation enhances the effect of roentgen rays on the skin, at least temporarily. There is no indication of a true antagonistic action.

3. The conclusions of previous investigators are, therefore, supported. It is inadvisable to use ultra-violet rays as emitted by a quartz mercury vapor lamp to counteract the effect of roentgen rays on the skin. Ultra-violet rays do not seem to hasten the healing of the acute roentgen ulcer if applied immediately after its appearance.

BIBLIOGRAPHY

(1) Pohle, E. A.: Radiology, 1926, VI, 236.
(2) Pohle, E. A.: Radiology, 1927, VIII, 185.
(3) Sampson, C. M.: Am. Jour. Roentgenol. and Rad. Ther., 1922, IX, 570.
(4) MacKee, G. M., and Andrews, G. C.: Jour. Am. Med. Assn., 1925, LXXXV, 1715.
(5) Pfahler, G. E., Klauder, J. V., and Martin, J. L.: Am. Jour. Roentgenol. and Rad. Ther., 1926, XVI, 150.
(6) Lane, C. G.: Archiv. of Derm. and Syphil., 1926, XIII, 237.
(7) Pohle, E. A., and Bunting, C. H.: Radiology, 1929, XIII, 496.
(8) Pohle, E. A., and Sawyer, R. A.: Am. Jour. Roentgenol. and Rad. Ther., 1928, XX, 338.
(9) Glocker, R., Hayer, E., and Jüngling, O.: Strahlentherapie, 1929, XXXII, 1.
(10) Hickey, P. M., and Pohle, E. A.: Radiology, 1929, XII, 309.

DISCUSSION

Dr. A. U. Desjardins (Rochester, Minn.): At several previous meetings I may have given the impression that I do not wholly approve of the physical method in measuring the quantity of rays. If I have given that impression, I want to correct it now. There can be no question but that physical methods of measuring quantity are essential to high grade work, but the reason I made those comments was not so much to make any one feel that physical methods of measurement were being overdone, but simply because I had come to know that many were thinking too much of the physical side of their work and not enough of the medical side. My feeling is that the more we stress the medical side, the better work we can do, providing the other side is properly taken care of also. Within the last year—three or four months ago, in fact—I heard two bank presidents and one fairly prominent economist, trying to tell a group of business men that the old principles of economics had gone by the board and that we were moving in a different world. Some of the answers given to Dr. Glasser's questionnaire remind me a little of these men, because any one doing therapy who says that the erythema can be disregarded, is in the same position as those business men who thought the old principles of economics could be disregarded—they have found out during the last four months that the old principles are still very strong. So long as we are dealing with human tissue or any living tissue, we must take into account every reaction of such tissue. It is absolutely essential to measure the quality and quantity of the rays, but the chief importance of using physical methods for measuring quantity and quality is that we can interchange information—understand one another.

I was greatly interested in the report by Dr. Pohle and Dr. Wright of their experiment, because they absolutely confirm the experiments made previously by Dr. MacKee and Dr. Andrews, of New York, and Dr. Pfahler, of Philadelphia.

Dr. W. E. Chamberlain (San Francisco): As I listened to Dr. Glasser's paper, it occurred to me that an experiment Dr. Newell and I carried out might be of interest to some of you. Long before the r-unit or the ionization chamber was heard of, the "MacKee formula" was used to measure and record X-ray dosage. This formula expressed dosage as the product of the milliamperage, the spark gap (in inches), and the time (in minutes), divided by the square of the distance (in inches). You will remember that Dr. MacKee gave thirty-six sixty-fourths as a skin unit dose, and forty-five sixty-fourths as his erythema dose. Now we want to know what these MacKee doses amount to in r-units.

Of course, one cannot give a set value in r to the skin unit dose of MacKee, because a certain milliamperage for a certain time, at a certain spark gap and distance, does not always produce the same quantity of X-ray or the same biologic effect. It is precisely because of this that dosage specifications of the MacKee type are being abandoned in favor of ionization measurements and the

r-unit. But it is of some interest to measure the number of r in a MacKee dose, for apparatus that has been biologically calibrated through treatment of many patients. In our own experience the skin unit dose of MacKee (thirty-six sixty-fourths) amounts to about 240 r, while the erythema dose (forty-five sixty-fourths) equals about 300 r (r measured in air, without back-scatter).

Whenever we discuss dosage measurement, I feel impelled to again call attention to the significance of the work of Dr. F. C. Wood and his co-workers with the eggs of the fruit-fly. Entirely aside from the problems already successfully attacked with these little "biological ionization chambers," they are admirably adapted to such studies as that of the effect of back-scatter upon surface intensity, or the percentage depth dose at a given distance below the surface. These questions have never been properly solved with the air bubble ionization chamber. In Dr. Glasser's paper, for instance, 40 per cent is accepted as the correct value of the increment in surface intensity due to back-scatter from a wide area. As a matter of fact, it is not at all certain that the small ionization chambers, heretofore used for the measurement of such values, are capable of giving a correct answer. I believe that Dr. Wood and Dr. Packard are now making measurements of this sort with the fruit-fly eggs. We await their publication with deepest interest.

My discussion of the paper of Dr. Pohle and Dr. Wright will be limited to asking a question: What of the use of the ultra-violet light ray in the treatment of late roentgen ulcers? Many of us, in the giving of repeated large doses of high voltage X-ray for cancer, have seen the occasional development, months or years after treatment, of deep ulcers, and of hard, indurated areas in the skin and subcutaneous tissues which are both avascular and telangiectatic, and which are prone to ulcerate but may be very painful even before any ulceration has taken place. It has been my impression that the quartz light is of great value in these conditions, and that very prompt relief of pain may be hoped for, even when healing of the ulceration is very slow. I would like to know what Dr. Pohle and Dr. Wright have to say on this subject.

LAURISTON S. TAYLOR (Washington, D. C.): In Dr. Glasser's paper he mentioned the comparison by Dr. Behnken of the standard chambers of the Reichsanstalt, in Berlin, and those of Dr. Glasser and Prof. Duane. At the instigation of radiologists, the Bureau of Standards several years ago commenced the problem of setting up a standard ionization chamber, and within the last month checked its standard unit against that established by Dr. Glasser some years ago. I tried to make such a comparison last Spring with the laboratory of Prof. Duane, but unfortunately the portable instrument carried to Cambridge was damaged in transit back to Washington and the work was of no avail, thereby delaying for nearly six months the actual calibration of instruments by the Bureau. To avoid this difficulty a second time, we had Dr. Glasser come to the Bureau with two instruments, the Victoreen and the condenser dosimeter, both of which previously had been calibrated at the Cleveland Clinic. We worked at two voltages at the Bureau—140 and 150 kilovolts—and two filtrations, 2 mm. and 4 mm. of aluminum. We chose these two particular sets of conditions because, at such operating factors, the wall correction for the small chambers would be comparatively large, so that if we obtained a fairly close agreement at these values, the indication would be that the agreement should be at least as close at higher voltages. I will say only that, repeating runs in the morning and afternoon of the same day, making, in all, I believe, six separate calibrations, the aver-

age agreement was about 2 per cent. I do not recall which unit was the larger. There was no reason to believe, in advance, that there would be any particularly large difference between the Bureau of Standards unit and that of Dr. Glasser. However, we thought it necessary to make such a calibration, to make sure that there were no "niggers in the woodpile" before we proceeded with the calibration of outside instruments. Beginning with the first of the year (1930), the Bureau will be in position to calibrate any ionometers or dosage meters sent in which have with them some means of calibration control. It will be perhaps dangerous and misleading to calibrate any instruments which do not have a radium or an uranium oxide control for checking the calibration before and after transit, inasmuch as there is a possibility of damage occurring to the electrometer system which could not be otherwise detected. In brief, any such instrument sent in after the first of the year will be calibrated in terms of the international r-unit, and we hope that this work will prove of sufficient value so that the various institutions may avail themselves of our assistance.

M. M. SCHWARZSCHILD (New York): We have been using 4,000 r-units for some time, with a filtration of 2 millimeters of copper and 200 K.V., constant potential. The dose is given in a short time, usually in seven days, over a series of portals, so that the total dose reaching the tissue is given in about twenty-one days. The dose on any portal, the total 4,000 r-units, is usually given in the course of one week. The mucous membrane reaction begins on the twelfth day, reaches its maximum about the twentieth day, and is completely healed at the end of the twenty-fifth day. The skin reaction starts on the twenty-second day, reaches its maximum on the thirtieth day, and heals on the fortieth day. The skin reaction is rather unusual, there being complete exfoliation and complete re-healing, new skin being formed over the portion radiated. [Slides were displayed, showing the progress of the reaction in a case of a child of ten, radiated over the arm.] The dose was measured with three different instruments, a Victoreen, a Mecapion, and a Siemens dosimeter. The three meters gave approximately the same results, 4,000 r for the complete skin dose. The dose was given with heavy filtration, 2 millimeters of copper, and high voltage—an effective wave length of about 0.11 Ångströms.

G. FAILLA (New York): When I received Dr. Glasser's questionnaire, I was somewhat surprised to find that it contained no direct request for the specification of voltage and filter in connection with the statement of the erythema "dose" in r-units, which the radiologist was expected to make. Nor was there any reference to the time interval during which the total dose was administered. I am not surprised, therefore, to find an extreme variation of "doses" from 250 to 4,000 r-units in the answers received. The results of this questionnaire bring out more clearly than I have ever been able to do at previous meetings, the pitfalls of the indiscriminate use of the r-unit.

The confusion which is evidenced by the results of the questionnaire has arisen from the fact that too much emphasis has been put on the quantity factor of the dose of radiation. The quantity factor is the only thing which is measured in r-units, but this alone by no means defines the dose. For instance, an erythema may be produced under certain conditions by the administration of 1,200 r-units *at one sitting.* The same degree of erythema, so far as external appearance is concerned, may be produced by 2,400 r-units, administered under the same conditions as above, *but in fractional treat-*

*ments extending over a period of several weeks.* From this example it is perfectly evident that the erythema dose specified only as 1,200 or 2,400 r-units is meaningless. If other important factors are not stated, one cannot form an estimate of the biological effect which a certain amount of radiation, stated in r-units, might be expected to produce. Thus in the above example the administration of 2,400 r-units would lead to a severe skin reaction if given at one sitting, but produces a slight erythema if the same amount is spread over a sufficient length of time.

In order to avoid any possible misunderstanding of my remarks I wish to state that I am not opposed to the use of the r-unit but to its misuse. Every radiologist should express the *quantity of radiation* administered to a patient in r-units, but with a full appreciation of the fact that this alone does not specify the dose of radiation. The notion that an erythema dose or any other dose can be expressed in r-units is erroneous, but is rather common. To a large extent this is due to the usual practice of calling physical instruments which measure the intensity of the quantity of radiation "dosimeters" or "dosage meters." I would suggest, therefore, that in the future such instruments be called *ionometers* or *ionoradiometers,* and thus avoid the implication that by the reading of an instrument of this sort a radiologist can express the dose of radiation administered to a patient.

Otto Glasser (closing): I was very much interested in Dr. Lorenz' paper because he gave a complete compilation of work which has been done in dosimetry, including that done in this country. He especially called attention to the valuable work of Prof. Duane, in Boston, who began his investigations many years ago. I often feel that Prof. Duane has not received the credit which he deserves in the subject of dosimetry.

In regard to Dr. Chamberlain's question as to whether or not we use the *Drosophila* eggs in our work, I would like to say this: In the questionnaire and in our paper, we made no use of the results of our own work except in adding our erythema dose in r-units, as shown in the table. This was done in order to avoid mixing our work with that of the questionnaire. We have used the fruit-fly eggs in some of our experiments and find that the reaction of radiation upon these eggs, as suggested by Dr. Wood several years ago, is one of the most satisfactory biological tests. We are sorry that we did not start to work on this test several years ago. We have used the eggs only about half a year, and, unfortunately, even in this short time, we have had various troubles and have had to start over again. In spite of this, the results have been quite satisfactory. When we mentioned in our paper the answer to our question as given by a prominent radiologist, you probably realized that this was Dr. Wood, who followed up his doses given to the patients by checks on the *Drosophila* eggs and by ionization measurements. Our preliminary results in radiating these eggs checked very closely with Dr. Wood's data, and he, on the other hand, had compared his doses on the *Drosophila* eggs with those measured with one of the instruments calibrated in our r-unit.

In regard to Dr. Failla's question, I would like to call attention to No. 6 in our questionnaire, "Do you measure these doses for various conditions of radiation?" All of the answers on the questionnaire gave definite data on the radiation quality used. We would not have used them if they had not contained this information. In several places in our paper we called attention to the fact that this is absolutely essential.

Dr. Schwarzschild's report of the use of relatively high doses (up to 4,000 r-units),

applied with high filtration (2 mm. Cu.), within a reasonably short time, leads to an interesting part of this problem. It is possible that in using heavier filtration, we are able to give a larger amount of radiation. That is a question that has not been entirely settled. According to our measurements, in dosage with gamma rays of radium in r-units, 2,000 r-units can be applied without any difficulty, producing, on the average, a skin effect which compares with the X-ray skin effect of about 600 r-units. It is, therefore, quite possible that there exists an ionization effect which we did not discover in our original measurements.

Dr. Pohle and Dr. Wright's paper is interesting, not only on account of the data presented, but also because of its importance in the study of the effects of combined radiations. Years ago I mentioned, at a meeting in Atlantic City, that I did not think we should employ but one type of wave length for the treatment of certain diseases, but that the whole future of radiation therapy very probably depended upon a proper combination of different types of wave lengths —X-ray plus radium, X-ray plus ultra-violet, etc. In other words, we must try to combine various parts of the electro-magnetic spectrum, and then, perhaps, we can improve the results of treatment. I feel that Dr. Pohle's paper is a step in that direction, even if it showed certain negative results in the special phases of the problem which he investigated.

Dr. Pohle (closing): I will answer Dr. Chamberlain's question first. In the introduction of our paper, we mentioned that we have observed, during the last few years, a limited number of patients showing late reactions following roentgen exposure, with ulcer formation in the center of the involved area. Our clinical impression was that irradiation of these ulcers with a quartz mercury vapor lamp had a beneficial influence; it undoubtedly promoted the healing. However, the telangiectasis in the area was not affected at all. It seems, therefore, that Dr. Chamberlain's and our clinical experiences agree.

I wish also to say a few words regarding Dr. Failla's discussion of the r-unit. There is a lot of truth in what he said, from the standpoint of the physicist, but let me consider this problem from a practical point of view. We all see, for instance, cases which have been treated in another laboratory and are in need of further care. So far as I am concerned, I am always extremely happy if the patient either brings with him or I can get by mail, a detailed record from the radiologist who saw him first, giving me all the factors of the technic used, including the number of r-units applied as measured either on the skin or in air. Then I feel so much safer in continuing the treatment. As you all know, the output of different machines, even if operated under apparently the same conditions, may vary considerably. A certain exposure as expressed in milliampere-minutes can represent a much higher or lower dose than assumed. From the macroscopical appearance of the skin alone, one can not judge the margin of safety in such a case either, but if the dose has been expressed in r-units, one can proceed much more intelligently.

# A STUDY OF THE HALOGENATED OILS EMPLOYED IN ROENTGENOLOGY

By D. L. TABERN, N. A. HANSEN, E. H. VOLWILER, and L. A. CRANDALL
Contribution from the Research Department of the Abbott Laboratories, and from the Department of Physiology and Pharmacology, Northwestern University, CHICAGO

FOR many years, iodized oils and certain of their derivatives have been employed for the purpose of administering iodine in slowly assimilable form. Their introduction into roentgenology has been based upon the empirical observation by Sicard and Forestier that they could be utilized for the roentgenographic visualization of certain body cavities. Progress in this field has been so rapid and so brilliantly successful that primary interest has been centered upon the application of the technic to as many purposes as possible. Quite naturally, too, the roentgenologist and the clinician have been more interested in the diagnoses made possible by the radiopaque oils than in their chemical nature and their pharmacologic behavior. With the field now fairly well mapped out, attention is being turned to improvements in media and technic.

Save for the rather meager experiments of Putnam (1) and of Pinkerton (2), no comprehensive studies seem to have been published regarding the preparation and chemical and pharmacologic tests of various halogenated oils and oil derivatives. Even in these experiments, no specific attempts appear to have been made to employ pure products or to subject them to chemical examination. For instance, Pinkerton employed "crude" lard and chaulmoogra oils containing large percentages of free fatty acids. No products other than the halogenated and unhalogenated oils themselves were included in these investigations.

Putnam found that brominized animal oils were apparently less irritant (as tested in the anterior chamber of the cat's eye) and more readily emulsified than the iodized oils then in use. It would seem doubtful if this method of testing closely simulates the conditions under which the oils are used in roentgenologic practice. In the opinion of Pinkerton, the properties of more rapid absorption and emulsification are, for radiological purposes, distinctly disadvantageous because they may cause unduly rapid absorption of the attached halogen.

Archibald and Brown (3) have called attention to some of the dangers associated with the introduction of iodized oils. In brief, a perusal of the extensive literature which has arisen regarding the use of iodized oils in roentgenology brings to light the following outstanding disadvantages:

(1) The iodized oils are unstable toward heat, light, and moisture. For instance, they are decomposed by sterilization at 100° C. and liberate iodine on exposure to sunlight.

(2) The iodine or iodides always liberated in the body may, over long periods of time, cause toxemia, irritation, or in hypersensitive cases produce iodism. This is especially true since massive doses (10 to 40 c.c.) are required and elimination is much prolonged. Furthermore, iodine medication is considered by many to be contra-indicated in tuberculosis.

(3) The cost is high, a factor which has greatly restricted the routine use of the iodized oils.

(4) Another limiting factor has been the high viscosity of the radiopaque oils. Even warmed to body temperature, satisfactory filling of sinuses is difficult and the in-

jection of smaller cavities and tubes, such as the seminal vesicles, is out of the question. Also because of this viscosity, drainage from cavities is very slow.

We were attracted to this problem by the apparent possibility of avoiding the first three of these disadvantages through the development of a suitable brominized oil. During our investigation, the fourth has been overcome as well through the synthesis of certain brominized esters of the oils. These possess radiopacities equal to the halogenated oils, but have only a small fraction of their viscosity. Since the brominized oils and brominized esters are miscible in all proportions, it now becomes possible for the roentgenologist to select an oil of any viscosity exactly suited for the conditions at hand.

## DISCUSSION—CHEMICAL

In view of the discrepancies to be found in the literature, every effort was made to employ oils of exceptional purity. Oils of known origin were secured and subjected to the standard tests for identity. They were next decolorized by Filtrol at 100° *in vacuo* until essentially water white. Free fatty acids were then removed by suitable means until 10 grams of the oil dissolved in neutral acetone required not more than 0.3 c.c. of N/10 NaOH to give a distinct pink color with phenolphthalein. That is, the free fatty acid content was below 0.1 per cent. Bromination was carried out by direct addition of the halogen at a carefully controlled temperature until the calculated halogen concentration was slightly greater than that desired in the finished product. Under these conditions the reaction is almost entirely one of simple addition. All acidic by-products formed and any solvents used were carefully removed at room temperature. In almost every case, the final product was analyzed for bromine by the Carius method. In every instance the acidity was less than 0.25 per cent when determined by the above method. As further means of characterization, the viscosities, densities, and refractive indices were determined at 25°.

The esters were prepared from the corresponding oils or acids by standard methods, and purified and brominated as described above. Except where specified in Table I, they were distilled in a vacuum of 5–10 mm., just prior to halogenation.

Benzyl oleate was synthesized according to the method of Shonle (4); glycol oleate was prepared by the interaction of potassium oleate and ethylene dibromide at 180° followed by fractional distillation at 4 mm.

In addition to those iodized oils commercially available, certain other typical iodized oils were synthesized. These were prepared either by the direct action of iodine in the presence of mercuric chloride or by the action of iodine monochloride in aqueous solution. The above criteria of purity were also applied to these oils.

From a chemical standpoint the most suitable products for roentgenographic use were secured when the parent oils were of vegetable rather than of animal origin. A group of brominized lard oils containing from 10 to 32 per cent of halogen were studied in detail; in addition to a tendency toward rancidity, the continuous formation of a flocculent precipitate offered serious objections to their use. Cod liver oil underwent extensive decomposition during bromination.

Among the so-called vegetable oils, olive oil was found to possess many advantages. It is relatively constant in composition and readily purified. It is almost entirely free from glycerides having more than a single double bond. A suitably prepared 33 per cent brominized olive oil may be heated to 120° for several hours without appreciable decomposition. Exposed to air and sunlight in the laboratory, it is not only perfectly stable, but even becomes lighter in color.

TABLE I

| Oil | | | | | Ester | | | | Brominized Oil | | | | Brominized Ester | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parent Oil | App. Iod. Number | Den. | Visc. $H_2O=1$ | Ref. Ind. | Name | Den. | Visc. | Ref. Ind. | % Hlg. | Den. | Visc. | Ref. Ind. | % Hlg. | Den. | Visc. | Ref. Ind. |
| Lard | 72 | 0.91 | 13 | 1.465 | | | | | 10 | 1.0 | 43 | 1.473 | | | | |
| | | | | | | | | | 20 | 1.09 | 51 | 1.481 | | | | |
| | | | | | | | | | 22 | 1.13 | 64 | | | | | |
| | | | | | | | | | 28 | 1.21 | 115 | 1.492 | | | | |
| | | | | | | | | | 32 | 1.23 | 129 | 1.494 | | | | |
| Lard | | | | | Ethyl | 0.869 | 1.6 | 1.449 | | | | | 13,14 | 1.0 | 4.1 | 1.460 |
| | | | | | | | | | | | | | 30 | 1.15 | 4.7 | |
| Lard | | | | | Allyl | | | | | | | | 40 | 1.27 | 8.6 | |
| Lard | | | | | Butyl | 0.86+ | 1.8 | 1.449 | | | | | 28(?) | | | 1.472 |
| Olive | 82 | 0.91 | 14.3 | 1.469 | | | | | 32 | 1.25+ | 178 | 1.499 | | | | |
| Olive | | | | | Methyl | 0.865 | ? | 1.449+ | | | | | | | | |
| Olive | | | | | Ethyl | 0.865 | 2.1 | 1.449 | | | | | 32,33 | 1.17 | 8.2 | 1.484 |
| Olive | | | | | Butyl | 0.860 | 2.3 | 1.451 | | | | | | | | |
| Olive | | | | | Octyl | 0.867 | 3.2 | 1.4525 | | | | | | | | |
| Cottonseed | 100–110 | 0.92 | 15 | 1.470 | | | | | 40 | 1.35 | 264 | 1.506 | | | | |
| Cottonseed | | | | | Ethyl | | | | | | | | 37,38 | 1.25 | 7.5 | 1.487 |
| Cod liver | 158–175 | 0.925 | | 1.480 | | | | | Decomposed | | | | | | | |
| Cod liver | | | | | Ethyl | ? | 4.1 | 1.468 | Decomposed | | | | | | | |
| Cod liver | | | | | Butyl | 0.875 | | 1.457 | | | | | | | | |
| Corn | 120–130 | 0.92 | 11.8 | 1.4715 | | | | | | | | | | | | |
| Corn | | | | | Ethyl | 0.875 | 1.4 | 1.454 | | | | | 35–37 | 1.23 | 14.5 | 1.489 |
| Linseed | 170–180 | 0.925 | 9.6 | 1.480 | | | | | 33 | 1.24 | 129 | 1.508 | | | | |
| Linseed | | | | | Ethyl | 0.875 | 1.4 | 1.46 | | | | | 33 | 1.05 | | 1.473 |
| | | | | | Ethyl | | | | | | | | 48% turned solid | | | |
| Castor | 85 | 0.963 | | 1.477 | | | | | | | | | | | | |
| Castor | | | | | Ethyl | 9.20 | 7.9 | 1.461 | | | | | 30 | 1.22 | 51.5 | Dark |
| Poppy | 140 | 0.92 | 17.5 | 1.472 | | | | | | | | | | | | |
| Poppy | | | | | Ethyl | 0.88 | 1.4 | 1.454 | | | | | 43 | 1.33 | 23.6 | 1.500 |
| | | | | | Ethyl | | | | | | | | 50 | | | |
| Rape | 96 | 0.915 | 16.8 | 1.470 | | | | | | | | | | | | |
| | | | | | Ethyl | 0.87 | 2.1 | 1.454 | | | | | 37(?) | 1.24 | 12.5 | 1.490 |
| Sesame | 105 | 0.915 | 12.5 | 1.4705 | | | | | | | | | | | | |
| | | | | | Ethyl | 0.87 | 1.4 | 1.452 | | | | | 40(?) | 1.27 | 12.1 | 1.492 |
| Stearic acid | | | | | Ethyl | 0.861 | 1.4 | 1.441 | | | | | | | | |
| | | | | | Butyl | 0.858 | 2.1 | 1.443 | | | | | | | | |
| Oleic acid | | | | | Ethyl | 0.872 | 1.6 | 1.4515 | | | | | | | | |
| | | | | | Butyl | 0.869 | 2.1 | 1.452 | | | | | 28(?) | 1.053 | 5.4 | 1.471 |
| | | | | | Benzyl | 0.869* | 2.9 | 1.486 | | | | | | | | |

*Shonle found 0.933.

The same valuable features are characteristic of the corresponding ethyl esters and their bromine derivatives.

For purposes of comparison the methyl, ethyl, butyl, and octyl esters of olive oil were prepared. Inasmuch as these did not differ sufficiently in their properties, and the increasing size of the alkyl group resulted in a lower total halogen content, the octyl ester was not halogenated.

It is at once obvious from Table I that the esters of the oils are much less viscous than the oils themselves and the same is true of the corresponding halogenated products. Expressed in terms of viscosity in seconds (with water taken as 1 second), 33 per cent brominized olive oil has a value of 170 seconds, while the corresponding ester is only 7 seconds. It is to be emphasized that inasmuch as the halogen content is the same in each, their radiopacities are identical.

The use of such a radiopaque oil derivative is believed to be an entirely new development in roentgenology. Clinical use has shown that for the visualization of cavities and tubes which are difficult to fill and slow to drain, such as the sinuses, seminal vesicles, etc., the use of an oil of low viscosity has many advantages. It has even been successfully used instead of the usual iodide solutions in pyelography, where its lack of irritating properties and its comparatively high radiopacity make it of value.

It is to be emphasized that inasmuch as the brominized oils and esters are miscible, by their simple mixture in predetermined proportions (as indicated in Chart I), an oil of any intermediate viscosity most suitable for the case at hand may be easily secured.

Another suggestive point is that the brominized olive esters approximate very closely the viscosity of the body fluids. Thus, pharmacologic experiments such as the delineation of mobile areas and of the circulatory system take on a new degree of accuracy, and entirely new fields of study are opened up.

The stability of their halogen when in contact with an aqueous medium suggests the value of the brominized olive oils and esters in the preparation of permanent radiopaque emulsions completely miscible with water. This phase is being actively studied at the present time.

## PHARMACOLOGIC STUDIES

Crandall and Walsh (4) observed that, contrary to popular supposition, Lipiodol and Lipoiodine, when injected intrapericardially and intrapleurally, produce marked irritation. Subsequent experiments demonstrated that under the same conditions brominized olive oil is less irritant. The question then arose, of course, whether the property of producing irritation resided primarily in the oil or in the halogen portion of the molecule.

The experiments outlined in this section of this paper were carried out essentially as outlined in the preceding article by Crandall and Walsh. Table II summarizes the pharmacologic data.

The irritation produced would seem to be independent of the degree of unsaturation, since both olive and linseed oils, particularly the former, are almost entirely non-irritating. It is indeed interesting to note that poppy and rape seed oils, both of which have been used as the parent substances for commercial halogenated oils, are the most irritant of the simple oils studied. Whether the oil is of animal or vegetable origin also seems to be unimportant, since lard oil falls midway between the above groups.

In general, the esters are somewhat more irritating than the oils, although the ethyl esters of lard and corn oils appear to be exceptions to the rule. Ethyl brassidate proved markedly irritating. In the group of homologous esters, the methyl and ethyl

are roughly equivalent, while the butyl and octyl derivatives are quite inert. In the same way, butyl stearate is less irritant than ethyl

Among the halogenated oils, 33 per cent brominized olive oil appears to be distinctly superior. The corresponding brom ethyl

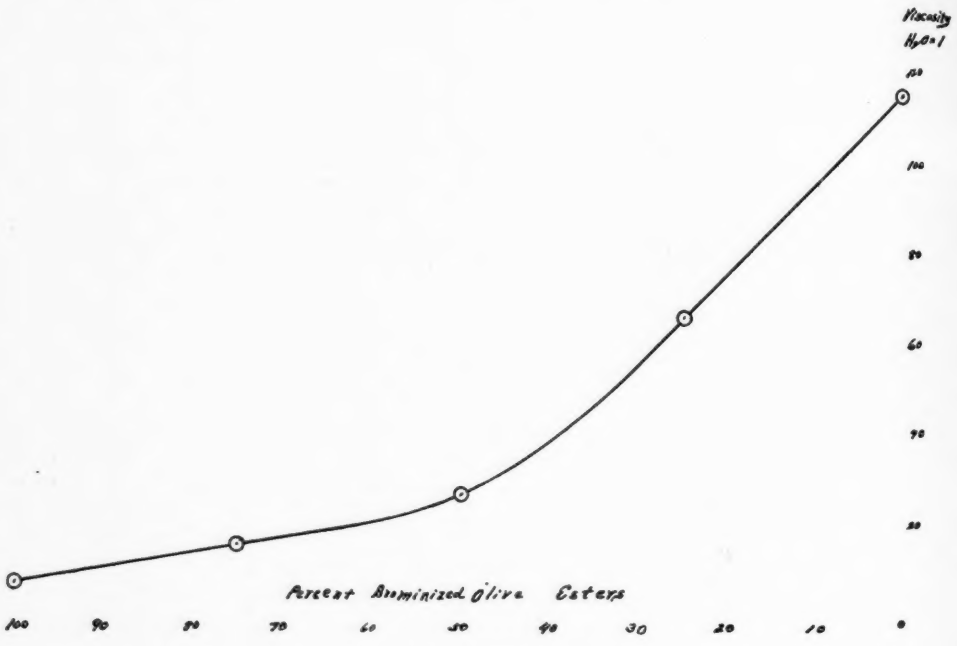



Chart I. (See text, page 367.)

stearate, and benzyl oleate appears better than butyl oleate.

To test the effect of the presence of pure fatty acids, varying percentages of pure stearic and oleic acids were added to olive oil. It was found that 0.5 per cent of stearic acid produced as much irritation as 5 per cent oleic.

The effect upon the esters of distillation at 10 mm. or less was tested. The distilled products proved superior, while the residue in the distillation flask was strongly irritating.

While castor oil produced no ill effects, the ethyl esters of this oil caused death without great irritation. This may well have been due to the rapid absorption of the ricinoleates present in the esters.

ester, while somewhat more irritating, is still slightly better than Lipiodol.

## ROENTGENOGRAPHIC STUDIES

The radiopacity of a substance is a function of its density and of the sum of the atomic weights of the constituent atoms. The type of function is, however, not a simple one, there existing absorption bands, just as in the selective absorption of certain wave lengths of visible light by colored substances. As an approximation, we may say that the absorption is proportional to the sum of the atomic numbers. On this basis, we might expect the ratios of the radiopacities of brominized and iodized oils of equal halogen content to be in the ratio of 1 to

TABLE II

| Name | Halog. content | Treatment of unhalog. compound | Irritation | |
|---|---|---|---|---|
| | | | Intrapleurally | Intrapericardially |
| Olive oil | — | Filtrol* F.F.A.F. | None | None |
| Brom olive oil | 33% | Filtrol F.F.A.F. | Slight | Moderate |
| Iodo olive oil | — | Filtrol—F.F.A.F. | Slight to moderate | |
| Olive methyl esters | — | Filtrol—F.F.A.F. | Slight to moderate | |
| Olive ethyl esters | — | Filtrol—F.F.A.F. | Moderate | Marked |
| Olive ethyl esters | — | Distilled | None | |
| Residue from dist. olive ethyl esters | — | | Moderate | |
| Olive butyl esters | — | Distilled | None | Moderate |
| Olive octyl esters | — | Distilled | None | |
| Brom ethyl olive esters | 33% | Filtrol—F.F.A.F. | Moderate | |
| Brom ethyl olive esters | 33% | Distilled | Slight | |
| Brom olive oil 85% Brom olive ethyl esters 15% | 33% | Filtrol—F.F.A.F. | Moderate | |
| Brom butyl olive esters | — | | Moderate | |
| Iodized ethyl olive esters | 40% (?) | Filtrol—F.F.A.F. | Moderate | |
| Olive oil + 1% oleic acid | — | — | None | |
| Olive oil + 5% oleic acid | — | — | None | |
| Olive oil + 10% oleic acid | — | — | Marked | |
| Olive oil + 0.5% stearic | — | — | None | |
| Olive oil + 1% stearic | — | — | Slight to moderate | |
| Olive oil + metaphen 1 : 5,000 | — | — | Slight | |
| Olive oil + metaphen 1 : 10,000 | — | — | None | |
| Lard oil | — | Filtrol—F.F.A.F. | None | |
| Brom lard oil | 33% | Filtrol—F.F.A.F. | Slight | |
| Lard ethyl esters | — | Filtrol—F.F.A.F. | Slight | |
| Lard ethyl esters | — | Distilled | None | Moderate |
| Brom lard ethyl esters | 33% | Filtrol—F.F.A.F. | Moderate | |
| Linseed oil | — | Filtrol—F.F.A.F. | None | |
| Brom linseed oil | ? | | Slight | |
| Linseed ethyl esters | — | Distilled | Moderate | |
| Poppyseed oil | — | Filtrol—F.F.A.F. | Moderate | |
| Lipiodol | 40% | ? | Moderate | Marked |
| Rapeseed oil | — | Filtrol—F.F.A.F. | Moderate | Mod.-Marked |
| Campiodol (dil. with ethyl olive) | — | | Slight to moderate | |
| Sesame oil | — | Filtrol—F.F.A.F. | None | Mod.-Marked |
| Cod liver ethyl esters | — | Mod. | Not done | |
| Castor oil | — | Filtrol—F.F.A.F. | Slight | |
| Ethyl esters castor oil | — | Filtrol—F.F.A.F. | Moderate† | |
| Ethyl oleate | — | Distilled | | |
| Butyl oleate | — | Distilled | None | |
| Brom butyl oleate | 30% | Distilled | Very slight | |
| Benzyl oleate | — | Distilled | None | |
| Glycol oleate | — | | None | |
| Ethyl stearate | — | Distilled | None | |
| Butyl stearate | — | Distilled | None | |
| Ethyl brassidate | — | Distilled | | Marked |
| Lipiodine | | | | Marked |

*"Filtrol" means "Decolorized with Filtrol." "F.F.A.F." means "Free fatty acid free."
†Died in 24 hours. No irritation.

1.5. It must be remembered, however, that, due to the smaller size of the bromine molecule, more of them will be found per unit area of halogenated oil. An approximate calculation shows this ratio to be 1 to 1.6, with the advantage on the side of the brominized oil.

Actual measurements made with brominized and iodized oils of equal halogen content, employing a six-inch spark gap and an oil depth of 10 mm., indicated the ratio of radiopacities to be in the order of 1:1.2. A comparison of 33 per cent brominized olive oil and 40 per cent iodized poppy seed oil gave values of 1:1.6.

Clinical experience has apparently shown that this slightly lower radiopacity is, for many purposes, an advantage. In sinus visualization, for instance, it has long been the custom to dilute the iodized oil with an inert solvent to decrease the radiopacity. Since with the brominized oil fillings appear not as areas of complete radiopacity but show gradations of shadow depending upon the thickness of the oil layer, better detail may be secured.

## CLINICAL EXPERIENCES

During the course of these studies the two products found to possess the most desirable properties have, through the kindness of a group of collaborators, been rather extensively tested in clinical practice. The first was 33 per cent brominized olive oil esters (Visc. 7 sec.), and the second, a mixture of 85 per cent brominized olive oil and 15 per cent of brominized olive esters (Visc. 120 sec.).

It was at once found that for the filling of nasal sinuses either by the "displacement method" (6) or by injection under pressure, the brominized olive esters offered many advantages both to the roentgenologist and to the patient. Obviously, filling is more rapid and more nearly complete; the films, because of the slightly lower radiopacity of the oil, are more satisfactory; and the time of drainage is reduced by many hours. Proetz has, in particular, stressed the importance of studying the rate of drainage.

In the visualization of the seminal vesicles according to the technic of Belfield and Rolnick, the brominized olive esters were found to be more satisfactory than the suspension of thymol iodide in oil previously employed.

The same product has successfully replaced sodium iodide solution in pyelography. Results thus far obtained indicate a complete lack of irritation. Because of the higher radiopacity of the brominized esters as compared with 12–20 per cent sodium iodide, the shadows were very dense.

The pressure required for the introduction of iodized oils into the uterus and fallopian tubes has been one of the disadvantages of this technic. It seemed probable that the brominized olive esters, because of their low viscosity, could be employed for this purpose, with a resultant decrease in pressure necessary for injection. Such, indeed, has been found to be the case. The uterus and the "spill" are normally well delineated, but unfortunately the tubes themselves are not so clearly outlined as when a more viscous oil is employed. The superior tubal visualization is probably due to distention by the very viscous oil.

It has been found that a surprisingly large number of patients become pregnant after the injection of radiopaque oils. It would seem probable that an oil of low viscosity would pass through and open up partially occluded or "sticky" tubes which would be quite impermeable to a heavy oil. This point deserves further careful study.

Without extensively multiplying examples, experience would seem to indicate that the 33 per cent brominized olive esters are particularly adapted for the visualization of those body cavities difficult to fill or slow to

drain. In experimental physiology and pharmacology, too, they appear to have opened up entirely new fields.

For visualization of the bronchial system, on the other hand, an oil of moderate viscosity is desirable to prevent "flooding" of the most dependent areas, and to insure delineation of the larger bronchi. The viscosity possessed by the mixture of 85 per cent of brominized olive oil and 15 per cent brominized esters is slightly less than that of the oils heretofore available, and was found to combine proper delineation with easier injection. The latter becomes an important factor in the transcricothyroid method, where the use of a small needle is much to be desired.

The greatest advantage in this field of the brominized oils just described would appear to be in the impossibility of producing iodism, especially in tuberculous cases, and in their greater margin of safety from the standpoint of irritation.

Save that its radiopacity sometimes is not entirely sufficient for the fluoroscopic delineation of the female pelvic organs in very fleshy portions, 33 per cent brominized olive oil has been successfully employed in the diagnosis of sterility. (See preceding discussion of Brominol Light.)

## SUMMARY

A rather extensive series of halogenated oils has been prepared and studied chemically, pharmacologically, and clinically.

Brominized oils, particularly brominized olive oil and the brominized esters obtained from olive oil, have been found to possess distinct advantages over the iodized oils in use: the brominized olive oil and olive oil esters are much more stable, have controllable viscosities without loss of radiopacity, are economical to manufacture and use, low in toxicity, and, of course, can not cause iodism.

Pharmacological experiments have shown that brominized olive oil is definitely less irritating to the pericardium and pleura than the iodized oils now in common use. Brominized olive esters are more irritating than brominized olive oil, but are not more irritating than the iodized oils.

Clinically, these two products—33 per cent brominized olive oil and 33 per cent brominized olive ethyl esters—have proved valuable and effective as contrast media in radiology, and appear to possess a number of practical advantages over the products heretofore in use.

## BIBLIOGRAPHY

(1) Putnam, Tracy J.: Some Brominized Oils for Radiographic Use: Preliminary Report. Jour. Am. Med. Assn., Oct. 2, 1926, LXXXVII, 1102.

(2) Pinkerton, Henry: The Reaction to Oils and Fats in the Lung. Archiv. Pathol., March, 1928, V, 380.

(3) Archibald, Edward, and Brown, A. L.: Dangers of Introducing Iodized Oil into the Tracheobronchial System. Jour. Am. Med. Assn., April 23, 1927, LXXXVIII, 1310.

(4) Shonle, H. A., and Row, P. Q.: New Benzyl Esters Possessing an Anti-spasmodic Action. Jour. Am. Chem. Soc., February, 1921, XLIII, 361.

(5) Crandall, L. A., and Walsh, E. L.: The Effect of Iodized Oils on Serous Membranes. Radiology, June, 1929, XII, 499.

(6) Proetz, Arthur W.: Visualization of Sinus Drainage. Ann. Otol., Rhinol. and Laryngol., December, 1927, XXXVI, 978.

(7) Belfield, W. T., and Rolnick, H. C.: Roentgenography and Therapy with Iodized Oils. Jour. Am. Med. Assn., June 12, 1926, LXXXVI, 1831.

# THE PRECISE MEASUREMENT OF X-RAY DOSAGE[1]

By LAURISTON S. TAYLOR, WASHINGTON, D. C.

WITH the increase in the use of X-radiation in medical therapy it has become more important to be able to express with some exactitude the actual amount of radiation being received by a patient. It is also necessary that this quantity be expressed in a common unit which is readily reproduced and in which there is no ambiguity.

## I.—INTRODUCTION

In practice there are three distinct operations necessary in order to describe the radiation at a given location: (1) The measurement of the radiation intensity by means of a dosage meter; (2) the calibration of the dosage meter against a standard which measures the unit of X-radiation exactly; (3) a determination of the wave length distribution of the total radiation. It is in the second part that the Bureau of Standards is particularly interested and more especially with the exact measurement of the unit which was defined at the Second International Congress of Radiology at Stockholm, July, 1928, as follows: . . . "the quantity of radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in one cubic centimeter of atmospheric air at 0° C. and 76 cm. mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current." This unit is called the "roentgen" and is designated by small "r."

In a recent paper Behnken[2] gives the results of his comparison of the unit between the laboratories of Grebe, Küstner, Holthusen, Duane, Glasser, and the Physikalisch Technischen-Reichsanstalt. According to his measurements there is a discrepancy of about 4 per cent between various laboratories. No explanation for these differences has been given, and it is assumed that they are traceable to experimental error. However, as a result of some preliminary measurements made at the Bureau of Standards with the co-operation of Dr. Behnken, it is evident that improper electrostatic field conditions within the ionization chamber could account for at least some of the variation. To test this, a single ionization chamber was used under the same X-ray conditions but with various combinations of potentials applied to the plates as shown below.

## II.—X-RAY GENERATING EQUIPMENT

During the above-mentioned comparisons of Behnken it was demonstrated very clearly at the Bureau of Standards that, from the point of view of regularity of action, a mechanically rectified system was unsuited to precise X-ray measurements.

The wave length energy distribution in the X-ray continuous spectrum excited by constant voltage can be expressed mathematically[3] and can be determined experimentally with fair precision[4] as a function of the X-ray tube voltage and other factors, such as target material, etc. The total energy varies approximately as the square of the voltage. Consequently, with a tube potential fluctuating in an uncertain manner—as the mechanically rectified case—the energy distribution with time becomes uncertain; and, due to the shifting of the short wave length cut-off voltage, the quality is uncertain, since the spectral range is constantly shifting. As a result it was decided to use

[1] Read before the Radiological Society of North America, Dec. 5, 1928. This is Research Paper No. 56, Department of Commerce, Bureau of Standards. Reprinted by permission.

[2] H. Behnken, Strahlentherapie, 1928, XXIX, 192.

[3] H. Behnken, Zeit. für Phys., 1921, IV, 241.

[4] T. Ulrey, Phys. Rev., 1918, XI, 401.

a kenotron rectified direct current source of high potential in which the voltage fluctuation or ripple was a minimum. Thus there is a constant energy distribution and constant quantum cut-off within narrow limits.

This must not be confused with the medical application, for Coolidge has shown[5] that for the requirements of medical treatment the direct and alternating high voltage sources are about equally effective.

The circuit used is of the Hull[6] and Webster and Henning[7] type shown in Figure 1. The main transformer $T_1$ has one end of the secondary $S$ grounded. The other end goes to the cathode and anode, respectively, of two 250,000-volt kenotrons of the newest type. The filament current for these is supplied by separate insulation transformers $T_2$. The condensers $C_1$ and $C_2$ are of the Meirowsky Pertinax type in single units of 0.05 μf each, thus avoiding the difficulty of series condensers. The two chokes $L_1$ $L_2$ have 12,000 henrys inductance and are wound on closed iron cores immersed in oil. Protective sphere spark gaps are placed across the kenotrons $K$, condensers, and X-ray tube.

The voltage is measured ordinarily by means of a large sphere gap, but an electrostatic voltmeter is available for control. An X-ray tube of the Coolidge 200 K.V. deep therapy type has its filament current supplied from storage batteries placed in a coronaless copper case in which the current is adjusted by remote control. The high tension system is of ¾-inch tubing carefully installed to eliminate any corona discharge with consequent unsteadiness. It was found unnecessary to have any corona to act as a "safety valve," since the circuit design eliminated the likelihood of severe surges. A 60-cycle 25 K. V. A. synchronous motor generator supplies all of the transformers in order to obtain best control. A carefully adjusted overload circuit breaker in the main transformer primary prevents the possibility of damage from any heavy current discharges in the system. It has not been found necessary to use any protective resistances next to the X-ray tube, as no evidence of gas has been shown with the tubes used.

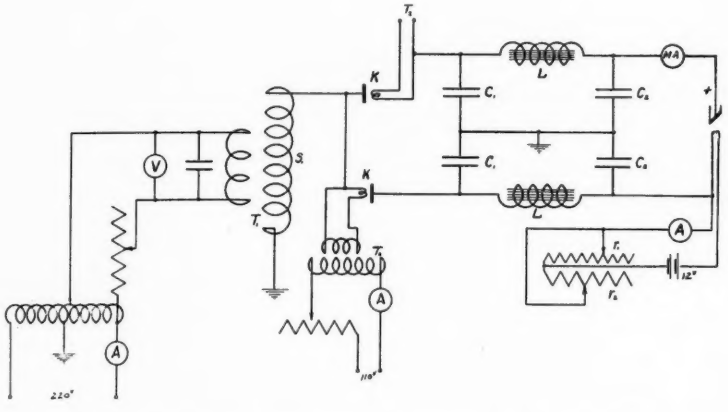



Fig. 1. Diagram of X-ray generating system showing controls.

[5] Am. Jour. Roentgenol., 1922, IX, 77.
[6] A. W. Hull, Am. Jour. Roentgenol., 1915, II, 153.
[7] P. L. Webster and A. E. Henning, Phys. Rev., 1923, XXI, 301.

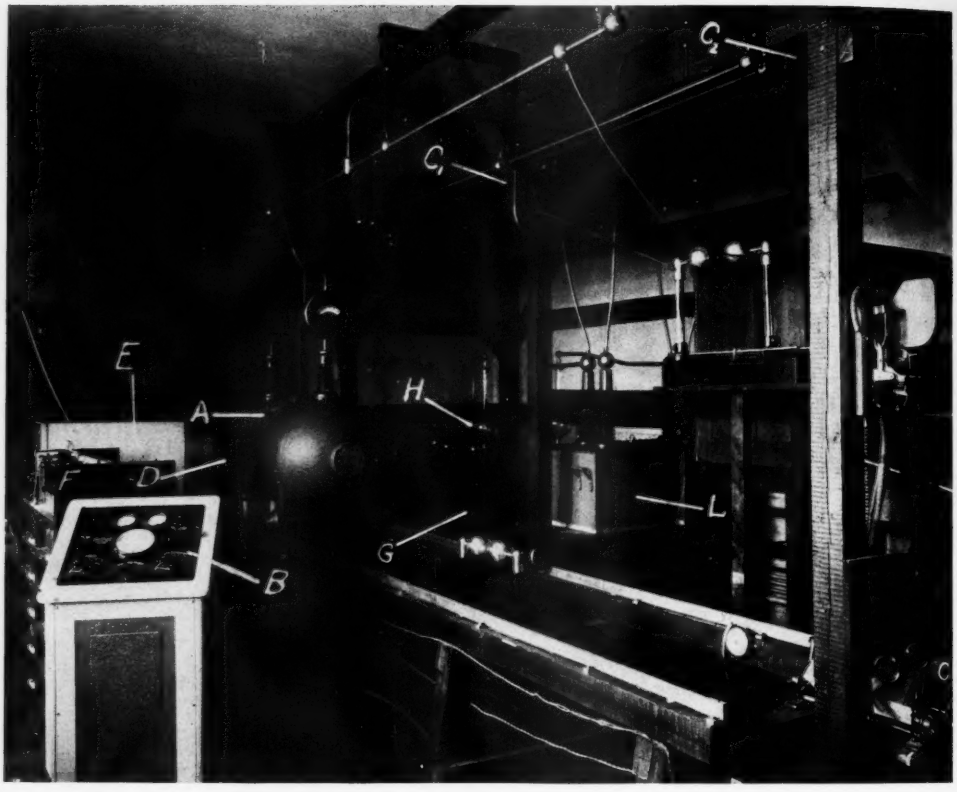



Fig. 2. General assembly of constant potential generator. *(L)* Choke coils; *($C_1$, $C_2$)* Condensers; *(A)* One-quarter inch lead tube shield; *(B)* Control panel; *(D)* Magnetic shutter; *(E)* Ionization chamber; *(F)* Fifteen-hundred volt battery; *(G)* Main transformer; *(H)* Kenotrons.

When making precise measurements a second operator controls the filament current and primary voltage. Under good conditions a precision of observation of 0.2 to 0.3 per cent can readily be obtained over a period of several hours. The variation from day to day, however, is frequently found to be double this amount.

### III.—IONIZATION MEASURING SYSTEM

It was decided from the start to use a large parallel plate ionization chamber as suggested by Duane[8] in his early work. The first form of Duane's chamber was not of sufficient size, and the guards were not properly placed. Using such a chamber at the Bureau with the co-operation of Dr. Behnken, mentioned above, the ionization current curve shown in Figure 3 was obtained where the current is plotted as a function of the chamber voltage. By analysis of this curve some approximate idea can be obtained of the field conditions within the chamber. This curve is shown because it is quite typical for a faulty system where the electrode potentials differ and was present in an early type of chamber when used with an idiostatic electrometer in place of a galvanometer.

To avoid this difficulty, a null electro-

[8]William Duane, Am. Jour. Roentgenol., 1922, IX, 467.

static measuring method is used. This has the advantage of being quite sensitive and being applicable for study of the field distortion as shown below. The galvanometer gives equally reliable results but does not have a sufficient range of sensitivity in the particular system.

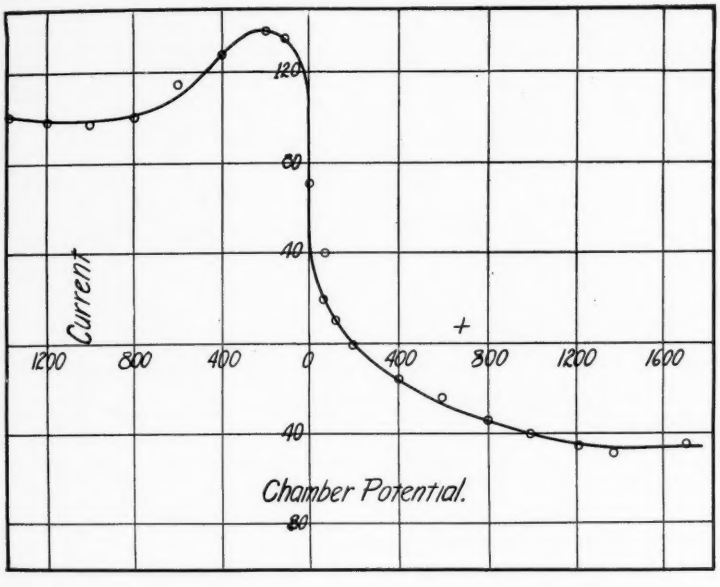



Fig. 3. Curve showing ionization current as a function of the chamber potential, using early model Duane chamber and Victoreen electroscope.

The final form of standard chamber is shown in Figures 4 and 5. The plate spacing is 10 cm. The measuring electrode is 10 cm. wide and the guards 20 cm. wide with a 0.5 mm. spacing between. The collector electrode is supported from the back by four amber posts bearing an aluminum yoke spread between the guards. All of the electrodes are mounted on a brass plate as shown in the photograph (Fig. 5). The guard plates are ordinarily earthed. The entire electrode system is placed in a ⅛-inch lead box with a ¼-inch lead front. The spacing between the high voltage electrode and the case was never less than the distance across the condenser normal to the beam (10 cm.). In the present chamber it is about 15 cm. Since the assembled unit is very large and heavy, it is mounted on an adjustable track so as to be readily aligned. Behind the ionization chamber is a lead chamber for preventing as much radiation as possible from escaping into the room. There is no measurable back-scattering from this chamber.

The diaphragm system is arbitrary, being approximately the same as used by Behnken[9] and Glasser.[10] More recent work by Failla[11] has indicated that these diaphragm systems are perhaps not exactly correct. In any case it was not altered throughout the entire period devoted to the experiments. About ½ cm. from the X-ray tube wall is placed a disk of 55 per cent lead glass 2 cm. thick and having in the center a 12 mm. hole. The position of this diaphragm is adjustable in all directions.

---

9H. Behnken, Strahlentherapie, 1927, XXVI, 79.

10O. Glasser, Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 47.

11G. Failla (seen in manuscript form).

The tube is contained in a ¼-inch lead cylinder lined with steel for rigidity. This is mounted on a 16-foot track so as to move into several positions.

An electrically operated lead shutter is mounted on the tube shield and controlled from the observer's position. The shutter system is similar to that used by Webster[12] and others, and the timing is independent of any uncertain electrical contacts. The shutter can be opened for any multiple of 7.5 seconds to within at least 1/1,000 second and avoids the use of a stop watch.

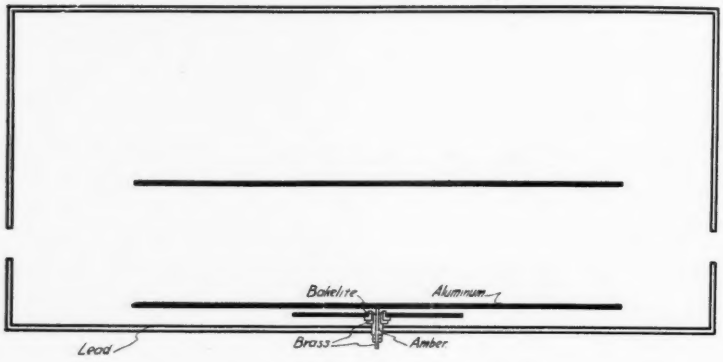



Fig. 4. Cross-section of ionization chamber.

Figure 6 shows the electrostatic measuring system. The electrometer and condensers are in a ⅛-inch lead box fastened to the chamber box. This provides electrostatic and X-ray protection. The system was carefully tested and all measurable leakage eliminated. $K$ is a Lutz-Edelmann fiber electrometer, which for the null readings was connected as shown with ±25 volts on each knife-edge. $C_1$ and $C_2$ are amber insulated concentric cylinder condensers, and $C_2$ (140 μμf) can be cut in and out of the system from outside the shield. For the purpose of null reading, on one side of $C_1$ a variable potential is applied by means of the coarse and fine rheostats $r_1$ and $r_2$. This is read on a precision voltmeter.

In making observations the electrode is first ungrounded and the shutter then opened. An observer maintains the cross hairs on the zero potential mark by continuously adjusting the rheostats $r_1$ and $r_2$ during the entire exposure. Thus, the potential of the collector electrode never differs from that of the guards by more than a small amount, which is determined by the sensitivity of the electrometer and the capacity of the system. In the particular case it was ±0.3 volt.

In such a method the potential necessary to counteract a given potential increase of the system depends solely upon the geometrical configuration of the system and is independent of the electrometer sensitivity. The electrometer sensitivity only limits the divergence of the collector potential from zero as shown above. A theoretical constant $k$ of the apparatus depending upon this configuration has been found experimentally to hold constant as long as the capacity of the system is unchanged.

If a change of potential $\Delta V$ between plates of the condenser $C_1$ produces a change $\Delta v$ on the insulated system, then

[12] D. L. Webster and A. E. Henning, Phys. Rev., 1923, XXI, 301.

$\frac{\Delta V}{\Delta v} = k_e$ when the condenser $C_1$ only is in the system. If in a time $t$ it is necessary to apply a potential $V$ to the condenser $C_1$ to maintain zero potential on the insulated system, then the corresponding charge $Q$ in e. s. u. due to the ionization is then given by

$$Q = \frac{C V}{k_e} \quad (V \text{ in e. s. u.}) \qquad (1)$$

$$= 0.9 \frac{C V}{300 k_e} \quad (V \text{ in volts and } C \text{ in } \mu\mu\text{f}) \qquad (2)$$

where $C$ is the total capacity of the system. Thus, under standard conditions of temperature and pressure, the dose in r per minute is given by

$$\text{r/min.} = \frac{0.9 \times C V \times 60}{300 \times t k_e W} \qquad (3)$$

where $W$ is the effective volume of ionized air and $C$ is measured in micromicro farads. Including next, the approximate correction for temperature $T$ (degrees absolute) and pressure $P$ (mm.)

$$\text{r/min.} = \frac{0.9\ C\ V \times 60 \times 273 \times \text{P}}{300 \times t k_e W\ T \times 760} \qquad (4)$$

The constant $k_e$ was determined carefully by charging the electroscope first directly from a potentiostat and then to the same scale points by means of the compensating potential applied to the condenser $C_1$. The curves in Figure 7 give the experimental relation between $V$, the compensating potential, and $v$, where $k$ is given by the slope. In the particular case only two capacities were used, but it is noticed that the relation is closely linear, and by taking the best line through the points a very accurate determination of $k$ is possible. In addition, this was tested, using a standardized variable condenser outside the case, and the same accuracy was found. In the expression (4) above, the ratio $\frac{C}{k_e}$ should be a constant for all capacities. This was found to be true over a wide range of electrometer sensitivities and from day to day. Thus the error introduced in r by certain other measuring methods due to the measurement of the volt sensitivity of the electrometer is eliminated.

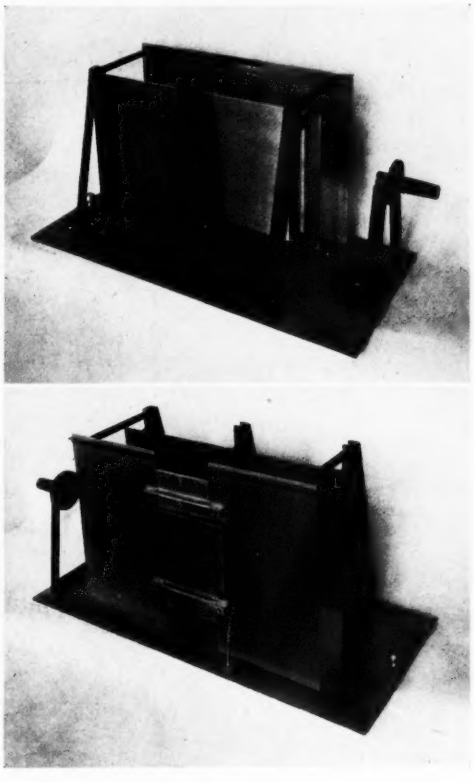


Fig. 5. Condenser plates composing the standard ionization chamber.

## IV.—RESULTS

The discrepancies between the various measuring methods are at once apparent from the saturation curves obtained by the same chamber under constant X-ray conditions. Four such curves are shown in Figure 8. In all cases the chamber potential was positive. (*a*) The electroscope was charged negatively and the discharge time from —50 to —32 volts measured. The saturation value was 3.55 r/min. (*b*) The electroscope was charged positively and the

charge time from +32 to +50 volts measured. The saturation value was 2.77 r/min. (*c*) The electroscope was again charged positively and charging time from +50 to —50 measured. (This can be considered as an average of *a* and *b*.) The saturation value was 3.15 r/min. (*d*) The null reading method gave a saturation value of 2.93 r/min. (*e*) Galvanometer method. (For the low energies used it was not practicable to determine the whole curve with the galvanometer, but above saturation it agreed within the experimental error with the null method.)

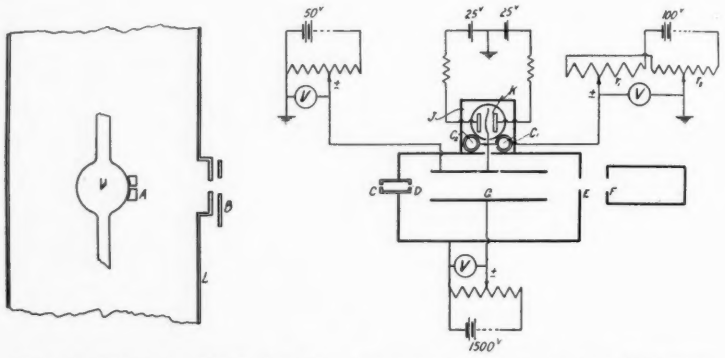



Fig. 6. Diagram of ionization chamber system. *(A)* Lead glass diaphragm; *(B)* Diaphragm and shutter on tube shield; *(C)* Diaphragm for defining the standard beam; *(D)* Diaphragm to reduce scattering of radiation within the chamber; *(E)* Diaphragm at back of lead box; *(F)* Lead box to stop radiation from entering the room; *(G)* Ionization chamber; *(J)* One-eighth inch lead box surrounding electroscope system; *(K)* Lutz-Edelmann Wollaston fiber electrometer; *(L)* Cylindrical X-ray tube shield.

Field distortion (to be described later) in the first two methods can account for the peculiar form of the curves. Glasser apparently recognizes this and then assumes that the distortion shown by curves *A* and *B* is equal and opposite, since he essentially uses Method C. Since, however, Method C produced a higher saturation value than D and E, the actual field distortion was carefully determined in the present case by experiment.

To study this, two methods were used which agreed within experimental error. With the chamber potential positive and well above saturation, the guard plates were set at zero potential and the electrometer system charged to various potentials from —45 to +45 volts. At each voltage value r was measured by the null method, maintaining the potential difference between guards and collector constant to within ±0.3 volts. Since $r = \text{const} \times V$ (equation (4)), a curve showing $V$ plotted against the potential difference between plates will give the difference in r according as the potential of the collector is above or below the guard. This is given by *C* in Figure 9. The value of r by the null method is that where the curve crosses the axis (78.4 volts in the particular case). The broken line *A* is simply the positive portion of the curve swung under the negative portion for more obvious comparison. Averaging these values it is seen at once from Curve *B* that the mean falls consistently *above* the value determined by the null method. In other words, the distortion produced when the collector is negative is greater than that when the collector is positive with respect to the guard

potential. A picture of the field for each case is given in Figure 10.

Exactly the same result was obtained when the collector was maintained at zero potential and the guards were set at the same potentials as above.

It may be said that the irradiated volume is determined by the cross-section of the beam and the bounding lines of force that just reach the collector at the edges. Thus it has been shown that due to controlled field distortion the length of irradiated volume varies in an unsymmetrical manner, the degree of dissymmetry depending upon the geometrical configuration of the system. This effect should be symmetrical when the width of the collector and the width of the guards are both very great with respect to the spacing of the condenser plates.

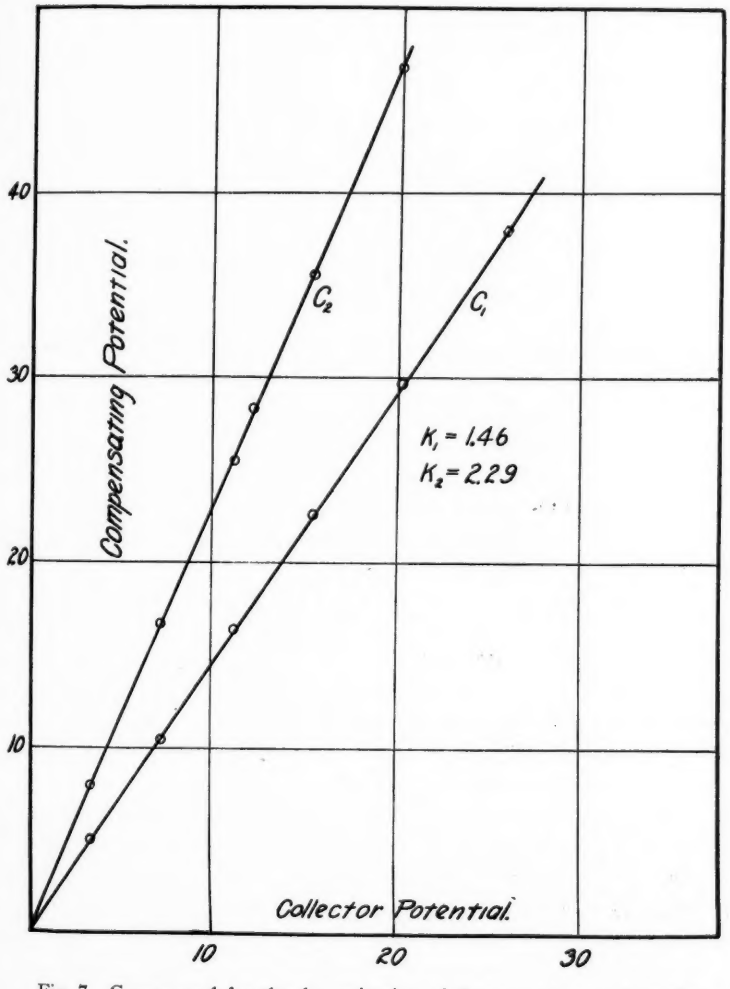



Fig. 7. Curves used for the determination of the apparatus constant "k."

Referring again to Figure 9 we may re-

gard the curves *A* and *C* as defining the irradiated volume limits for different potential differences between guard and collector.

tion chamber decreases slightly after the plate spacing reaches a certain maximum. This could be avoided in his chamber by

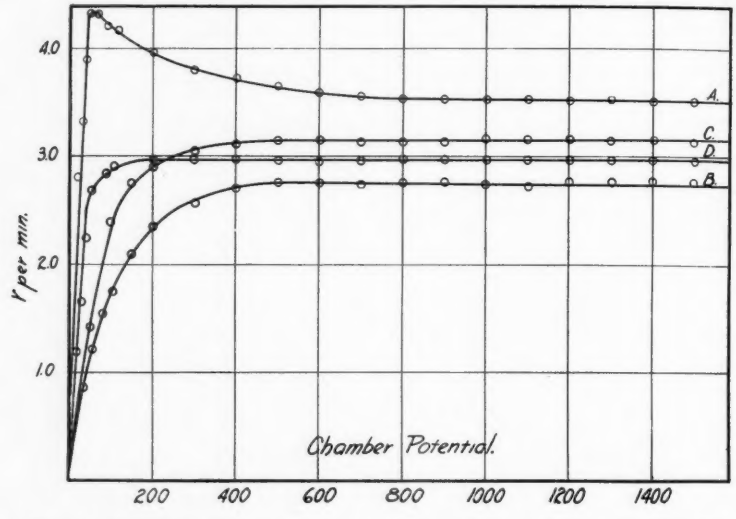



Fig. 8. Saturation curves for standard ionization chamber using different measuring methods. *(A)* Using a discharging, fiber electrometer; *(B)* Using a charging, fiber electrometer; *(C)* Using an idiostatic fiber electrometer; *(D)* Using a null reading fiber electrometer.

The average Curve *B* then indicates the change in length of the irradiated volume and the corresponding error introduced by a potential difference between the guard and collector, such as caused by the use of an idiostatic electrometer.

Rosa and Dorsey,[13] in their work with precision guard plate condensers, have calculated the error due to a very small displacement between the guards and collectors if their potentials differ. A measurable error of this kind was found by displacing the collector plate in the present ionization chamber when using the deflection method of measurement. It is not likely, however, that this error has been of any large amount in the work of others.

In a recent paper Duane[14] reported that the saturation current for a similar ionization chamber decreases slightly after the plate spacing reaches a certain maximum. This could be avoided in his chamber by placing the shielding diaphragm at the same potential as the high potential plate. This is avoided in our present chamber by spacing the shield at a sufficient distance from the electrodes. G. Failla[15] has independently substantiated this.

In the comparison made by Behnken[16] it was found that the Reichsanstalt unit agreed with that of Duane. An analysis of the method used by Behnken shows that there is only a fraction of a volt difference of potential between the guards and collector in his pressure chamber. His disagreement with Glasser's value is in the same direction and of the same order of magnitude as found in the present experiments. Thus, it is indicated that the mehods used by the Physikalische-Technischen Reichsanstalt and the Bureau of Standards should be in good agreement and should each yield an

[13] E. B. Rosa and N. E. Dorsey, Bureau of Standards Bulletin III, 433.

[14] William Duane, Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 461.

[15] See footnote 11, p. 375.

[16] See p. 372.

accurate determination of r when other errors are eliminated.

An analysis of the measuring method used by Glasser,[17] and as a secondary method by Behnken,[18] can be made experimentally by two simple operations. The guards are set at a fixed potential of such value as to bring the electrometer fiber, when at the same potential, to a sensitive position on the scale. The electroscope is then charged to a value somewhat higher than this. Times of transit are then measured with a split second stop watch between every five divisions on the scale. The voltage sensitivity curve of the electrometer is shown in *A* (Fig. 11) and is seen to be continuously changing. The point *a* on the sensitivity curve corresponds to the guard plate potential (147 volts). Points *b* and *c* correspond to equal voltage steps above and below *a*, through which range the electrometer is discharged; *b'* and *c'* are the corresponding time points. The corresponding transit time Curve *B* for the electrometer discharging is given below and is also seen to be continuously varying. The formula used in calculating (4) from these data is given by

$$\text{r/min.} = \frac{C \times V \times 60}{300 \times W \times t}$$

where $V$ in this case is the volt sensitivity. From the curves above the ratio $\frac{V}{t}$ can be obtained in any suitably small increments.

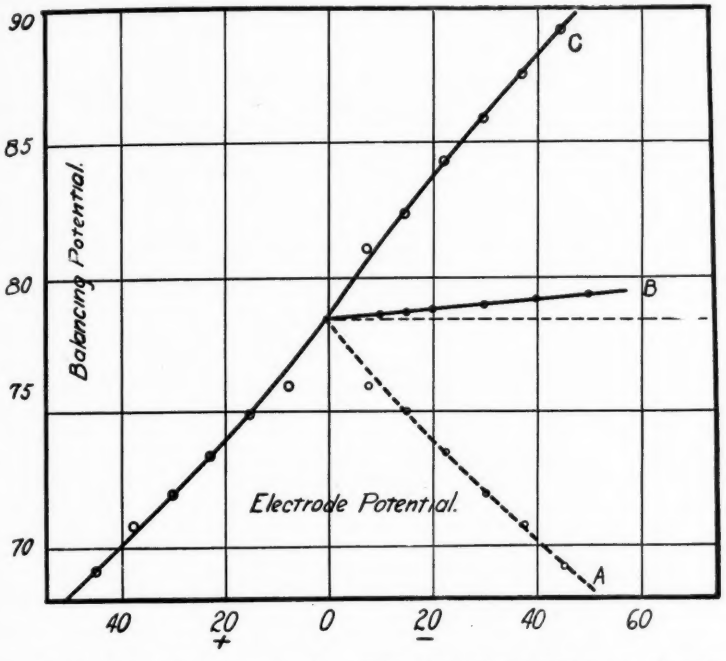



Fig. 9. Saturation current in the standard ionization chamber as a function of the potential difference between the guard plates and collector plate. Curve *B* shows the average saturation current for corresponding positive and negative potential differences. (Balancing potential is proportional to the saturation current.)

[17] O. Glasser, Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 47.

[18] H. Behnken, Strahlentherapie, 1927, XXVI, 79.

Thus, in order to determine r/min. accurately the ratio $\frac{\Delta V}{\Delta t}$ should be either constant or linear with respect to the scale position. However, in this particular case the ratios obtained from the curves in Figure 11 when plotted against scale position gave a non-linear relation as indicated in Figure 12. It is thus clear that under ordinary circumstances the above method will not yield an accurate determination of r/min. It must be pointed out, however, that if a sufficiently small voltage range is used, the error will not be large, since the relation is nearly linear for short ranges of voltage.

Also, it is probable that by varying the gap between collector and guards this non-linearity may be increased or diminished, thus changing the error introduced. When the above method of measurement is used, the error should be carefully studied and proper precautions be taken to eliminate it or reduce it to a minimum.

There is yet another source of error detectable when using a comparatively highly charged collector or guard plates. A small amount of secondary radiation scattered by the air may actually pass between the guards and collector, producing ionization both between the guards and collector and in the space behind them. In the first case the ionization current changes direction as the collector potential passes that of the guards. The error introduced is thus additive in one case and subtractive in the other. In the second case the ionization will be constant provided saturation exists behind the plates. When employing a null method

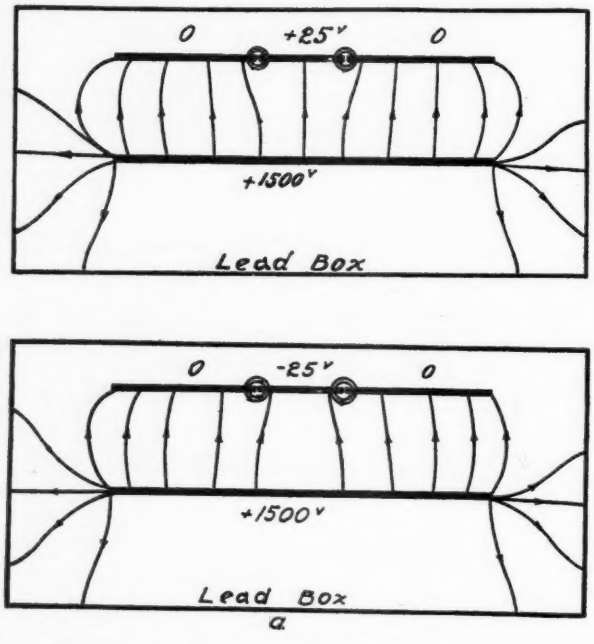



Fig. 10. Probable electrostatic field diagram in the standard chamber. *(A)* When using a discharging electrometer; *(B)* when using a charging electrometer.

in which the collector, guards, and box are all at zero potential, these errors will be absent.

## V.—ACCURACY OF MEASUREMENTS

The actual error in the present measuring system can be approximately determined. It

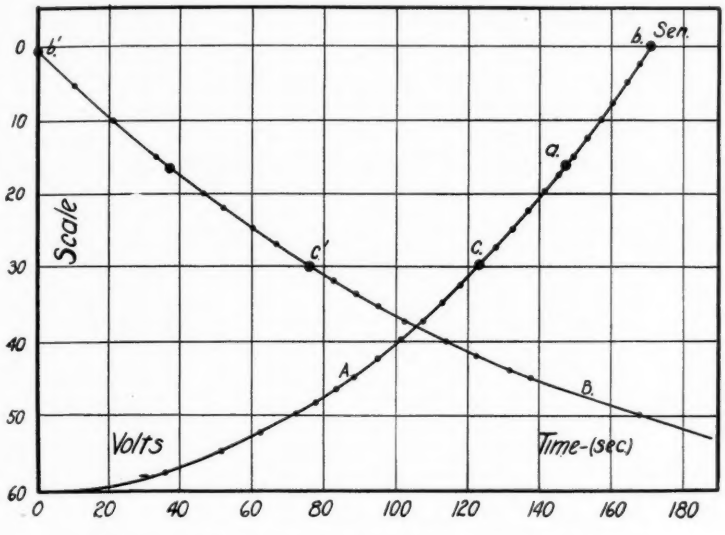



Fig. 11. Sensitivity curve and time-transit curve for idiostatic measuring method.

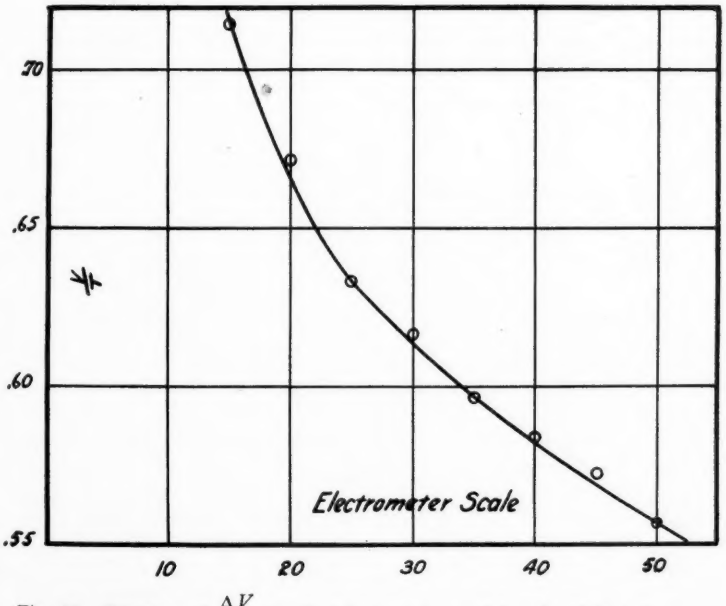



Fig. 12. Relation of $\frac{\Delta V}{\Delta t}$ to $V$ (electrometer scale) using idiostatic measuring method.

must be emphasized, however, that an arbitrary diaphragm system has been used thus far and the error in determining the volume $W$ of air ionized has been omitted. For an accurate measurement of r/min. this should, of course, be known.

The primary voltage on the high tension and filament transformers is measured to within ±0.1 volt. The ripple or fluctuation in the rectified voltage is calculated with sufficient accuracy[19] and found to be approximately 0.2 per cent when a current of 1.0 ma. is being drawn. The X-ray tube current is controlled to within ±0.005 ma.

When using the compensating potential the mean deviation of a number of readings is usually found to be 0.2 to 0.3 per cent. The voltage can be read to ±0.1 volt out of 100 volts, and the meter is accurate to 0.25 per cent. The capacity of the system is measured by means of a bridge calibrated at the Bureau of Standards. The capacitance can be determined with an accuracy of 0.5 per cent or better. By referring to the curves in Figure 6 for the determination of $k$, it is shown that the ratio $\frac{C}{k} = \text{const.}$ This also serves as a check on the capacitance measurements. It is thus seen that aside from the diaphragm error the accuracy in the determination of r/min. is 1.0 per cent or better.

19L. B. Jolley, Alternating Current Rectification. J. Wiley & Sons, 1924.

# EFFECTIVE *versus* SPHERE GAP VOLTAGES

By A. MUTSCHELLER, PH.D., NEW YORK

IN order to lend the weight which it deserves to the recent article by J. W. Du Mond and Archer Hoyt, of the California Institute of Technology,[1] there are herewith published additional data in support of the conclusions of this article, which have been measured by the writer and his assistants during several years just past.

That the dependability of the sphere gap for measuring high voltages applied to X-ray tubes has been very much overrated in the past, is well known to physicists; yet, despite that fact, the rating of therapy apparatus and the definition of radiation qualities have been almost entirely carried out with the sphere gap.

By a rather simple but nevertheless sufficiently accurate method[2] the author has photometered the minimum wave length and calculated the actual effective voltage in the X-ray tube from spectra taken with the Seemann Spectrograph. This method was selected because of the variety of conditions presented in the various rectifiers, some of which may have condensers while others may be producing pulsating current of quite varying wave forms. By measuring the voltage of each of these different types of apparatus by the various methods known, the fact is revealed that the minimum-wave-length method is the one most nearly in relation with the actual penetrative value of the rays employed. In particular, when correlating depth doses, it has been found that the minimum-wave-length voltages are the best index of the radiation quality and the depth doses obtained.

In the following list of minimum-wave-length voltage determinations from spectra of twelve different high voltage mechanical rectifiers, made in four different factories,

TABLE I

| Test No. | Manufactured by | Kilovolt sphere gap measured | Kilovolt minimum wave length from spectrum | K.V. Spark gap × 100 / K.V. Minimum wave length |
|---|---|---|---|---|
| 103 | B | 210 | 160 | 131 |
| 107 | A | 200 | 145 | 138 |
| 109 | A | 198 | 147.5 | 143 |
| 110 | A | 200 | 149 | 134 |
| 113 | A | 200 | 144.5 | 139 |
| 114 | D | 175 | 155 | 113 |
| 115 | D | 195 | 120 | 115 |
| 118 | C | 200 | 176 | 113 |
| 120 | A | 196 | 152 | 129 |
| 121 | B | 130 | 110 | 130 |
| 124 | C | 192 | 168 | 115 |
| 131 | A | 200 | 148 | 135 |

it appears that the magnitude of the difference between sphere-gap-measured voltages and minimum-wave-length voltages depends on the type of the rectifier, or, in other words, the constructional features seem to determine the magnitude of the discrepancies. All the apparatus manufactured by A shows the largest difference; the sphere-gap-measured voltages are an average of 135 per cent of the minimum-wave-length voltages. A second type, manufactured by B, gives sphere gap voltages of an average of 130 per cent of the minimum-wave-length voltage. Two other types, manufactured by C and D, give concordant results of sphere-gap-measured voltages of an average of 114 per cent of the minimum wave length.

Types A and B differ from Types C and D by the presence of large surfaces in the secondary circuit. The apparatus recommended as "coronaless" possesses large area rectifiers, large diameter and long aerials, sphere gaps, etc., thereby differing from the Types C and D. Type A includes also some rectifiers of very large dimensions, due to which they produce characteristics which are similar to those of the "coronaless" apparatus.

[1] RADIOLOGY, January, 1930, XIV, 62.
[2] RADIOLOGY, May, 1929, XII, 388.

The serious consideration of these facts is important for two reasons:

(1) The welfare of the patient requires that a measure of high tension voltage be employed which is proportional to depth doses, and, to obtain reliable results, the above correction factors should be applied if voltages are to be measured with the sphere gap;

(2) If the life of X-ray tubes or their general performance is considered, then such comparisons should not be made on the basis of sphere-gap-measured voltages, but of minimum-wave-length voltages.

It is evidently unfair to claim superiority in tube performance and longer tube life for any one type of apparatus if the secondary voltages are measured with the sphere gap for, quite evidently, the better performance so obtained runs parallel with a proportionally poorer radiation quality and smaller depth doses.

In the interest of the patient and of fairness, the facts presented by Du Mond and Hoyt and by the present author should be given earnest consideration by clinical therapists.

# THE EFFECT OF TECHNIC ON THE SPEED OF INTENSIFYING SCREENS

By FRANK E. SWINDELLS, PH.D., Research Chemist, the Patterson Screen Co., TOWANDA, PA.

CONSIDERABLE interest has been shown by many users of screens in the action of intensifying screens under the varying conditions of radiographic technic. It has been thought advisable, therefore, to make a study of the effect of changes in the following factors on screen speed:

1. Tube potential,
2. Tube current,
3. Target-film distance,
4. Interposition of filtering medium between target and film,
5. Development time.

The experimental method is given in detail elsewhere (1). The exposures are made by means of a sensitometer, which is a mechanical device used to produce a series of exposures of increasing time. A piece of film is partially covered with intensifying screens, and the whole is exposed in the sensitometer, all factors being maintained constant during the exposure. After development, two series of densities are thus produced on the film, one resulting from the action of X-rays alone, and the other from the combined action of X-rays and fluorescent light from the intensifying screens. Such a strip of film is shown in Figure 1. Numerical values are obtained for these densities on a densitometer, and the results shown graphically by plotting the density as a function of the common logarithm of the exposure time. This is the usual Hurter and Driffield method of plotting curves used in photographic sensitometry. A pair of such curves is shown in Figure 2.

The intensification factor is defined as the ratio of two exposures required to produce the same density, one exposure being made with the aid of screens and the other with-

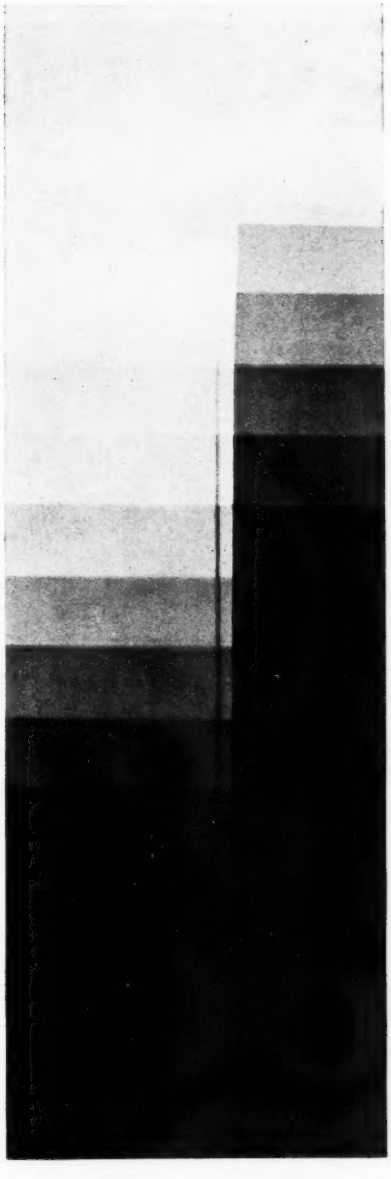


Fig. 1. Sample exposure. Note that in this figure the densities are reversed, *i.e.*, the darkest part of the original film is reproduced as the lightest part of the illustration, and *vice versa*.

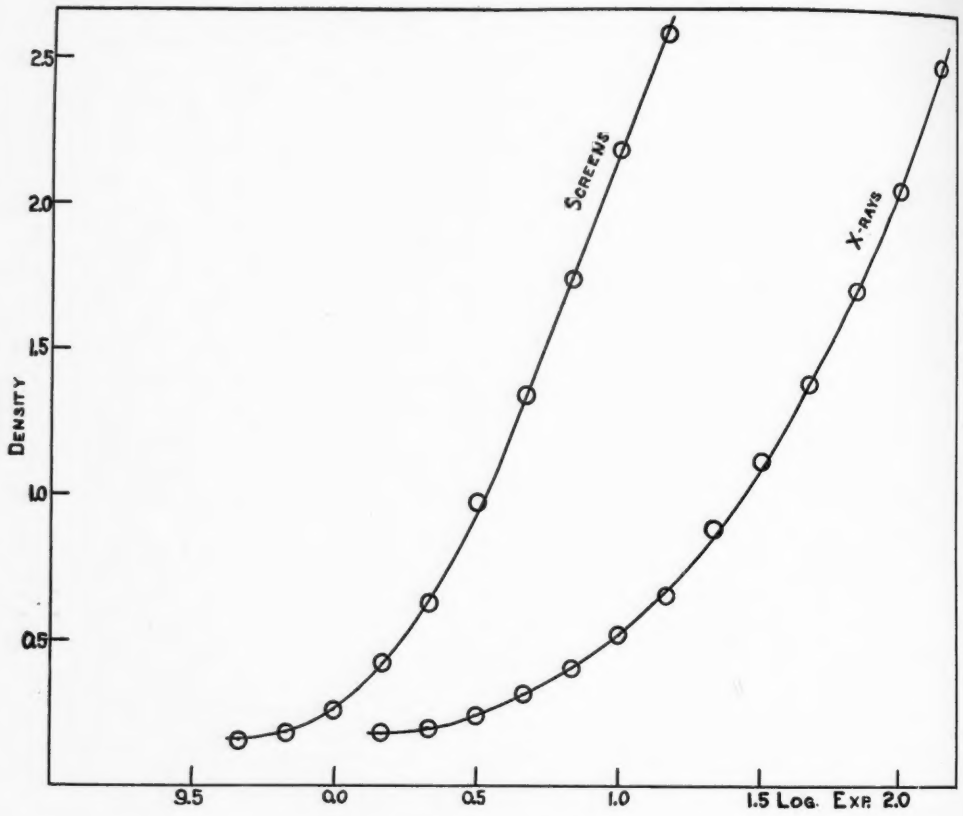



Fig. 2. Sample sensitometric curves.

out. This quantity is readily derived from the above described curves. Since the curve representing the exposure by X-rays has a different shape from that of the screen exposures, the intensification factor is dependent upon the density for which it is calculated, as described previously (2). For the sake of simplicity, the results which follow are calculated at a density of 1.0 (10 per cent transmission of light through the radiograph), which is assumed to be the average density of a radiograph. It should be recognized that when the very light portions of the radiograph are being considered these values are too high.

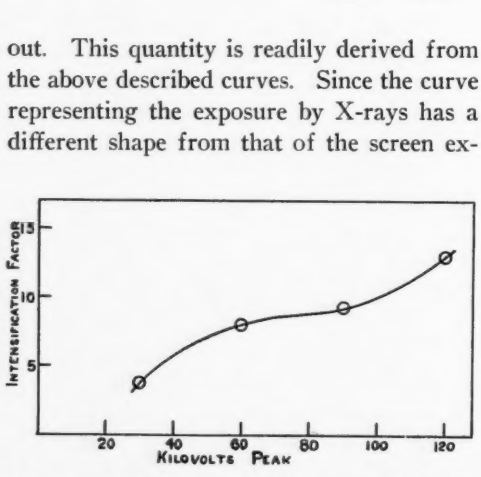



Fig. 3. Variation of intensification factor with tube potential 10 ma., 0.5 m. distance. Dotted line represents special combination with thin front screen.

The results to follow were obtained with a Coolidge broad focus universal tube, energized by a mechanically rectified machine. A filter of 2 mm. of aluminum was used in all of the exposures. Freshly prepared X-ray developer was used, at a temperature of

18.4° C. (65° F.). All exposures were made on films from the same emulsion, as indicated by the maker's number.

It has been previously determined (3, 4) that with increasing tube potential there is

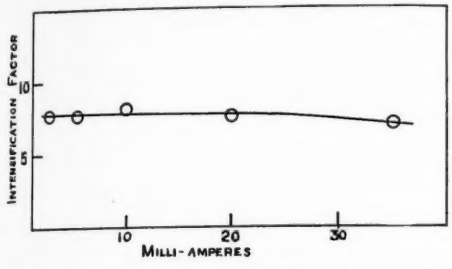



Fig. 4. Variation of intensification factor with tube current 50 K.V., 0.5 m. distance.

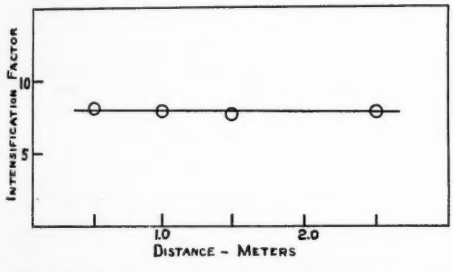



Fig. 5. Variation of intensification factor with target-film distance, 60 K.V., 10 milliamperes.

a corresponding increase in the intensification factor, and the measurements shown in Figure 3 confirm this observation. These determinations were made from a series of films exposed in the sensitometer in which the tube current and distance were kept constant at 10 ma. and 0.5 m., respectively, and the tube potential varied from 30 to 120 K.V.P., as determined by a sphere gap. There are two factors responsible for this variation. First, X-rays of different wave lengths have different relative abilities to expose the film and to excite the screens to fluorescence (5), and second, the varying absorption of the front screen for X-rays of different wave lengths, results in a diminution of the intensification process at lower voltages. From the curve it will be seen that the combined result of these effects is an increase in the intensification factor as the potential is raised. It is interesting to note in this connection that at extremely low values of the potential, such as are used

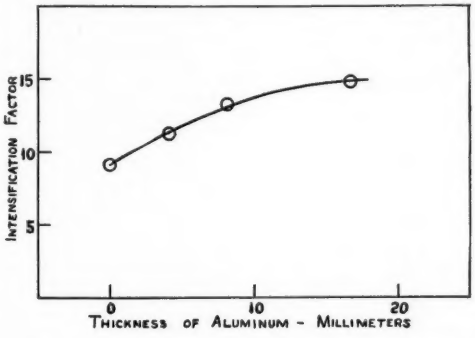



Fig. 6. Effect of absorption by aluminum, 90 K.V., 10 ma., 0.5 m. distance.

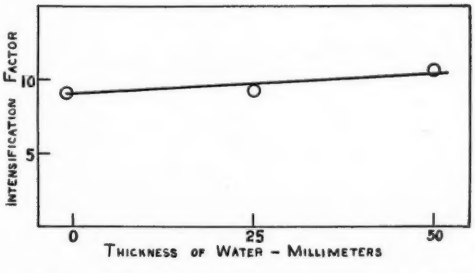



Fig. 7. Effect of absorption by water, 90 K.V., 10 ma., 0.5 m. distance.

in soft tissue work, the absorption of the front screen becomes so great that it is actually more efficient to use a single back screen instead of the combination.

In the next series, shown in Figure 4, the K.V.P. and distance were kept constant and the tube current varied from 2 to 35 milliamperes. The intensification was found to decrease very slightly with increased tube current, but the decrease was too small to have any practical significance. In Figure 5 the target-film distance was varied and again practically no change was found.

The effects of two types of absorbing media were then examined, and, as shown in Figures 6 and 7, in both cases there was an

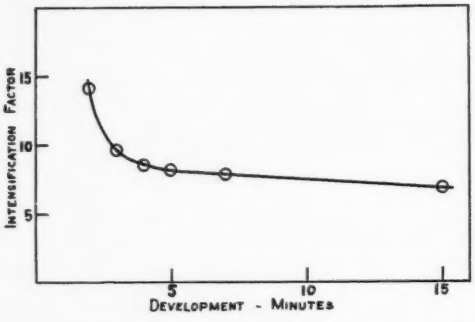



Fig. 8. Variation of intensification factor with development time, 60 K.V., 10 ma., 0.5 m. distance.

increase in screen factor with thickness of filter. Thus both with water, which produces a larger amount of secondary radiation, and with aluminum, which produces a small amount, the increase in hardness of the original beam was found to overbalance the effect of the softer secondary radiation. In other words, after passing through an absorbing medium, a greater proportion of soft rays, which are relatively less effective in producing fluorescence than in exposing silver bromide, is removed from the beam. The filtered beam then contains a greater proportion of the harder rays, which are relatively more effective in promoting screen fluorescence than photographic effect, and thus the intensification factor is increased. The practical significance of this experiment is that when a body to be radiographed is placed between the tube and cassette, a small increase in the intensification factor is obtained.

In Figure 8 the effect of changing the development time is shown. As the development time is decreased from the normal time of five minutes the intensification factor is found to increase considerably, but over-development has but little effect. This increase in efficiency of the screen cannot be utilized practically, for with under-development a more intense exposure must be given both with and without screens to produce the required density.

In summarizing, the following factors are found to have little or no effect on the screen speed:

1. Target-film distance (0.5–2.5 meters);
2. Tube current (2 to 35 ma.);
3. Over-development.

The following factors produce an increase in the intensification factor:

1. Increase in tube potential;
2. Increase in thickness of absorbing medium;
3. Under-development.

REFERENCES

(1) SWINDELLS, F. E.: Jour. Opt. Soc. Am., 1930, XX, 51.
(2) SWINDELLS, F. E.: Am. Jour. Roentgenol. and Rad. Ther., 1927, XVII, 115.
(3) FARRER, J. G.: Brit. Jour. Radiol., 1927, XXXII, 368.
(4) WILSEY, R. B.: RADIOLOGY, 1924, II, 311.
(5) DE BROGLIE, M.: Compt. rend., 1920, CLXX, 1053.

# MESENCHYMATOUS TUMORS OF THE LUNG AND PLEURA[1]

By I. PILOT, M.D.

From the Department of Pathology and Bacteriology, University of Illinois College of Medicine, CHICAGO, ILLINOIS

WITHIN the past ten years a greater incidence in primary carcinoma of the lung has been observed (1). Mesenchymatous tumors, both benign and malignant, however, continue to be considered very rare primary newgrowths of the lung. Adler (2) states that primary sarcoma of the lung is a great rarity, and he did not observe a single case, but he believed the extreme rarity of such growths might be exaggerated. He collected 94 sarcomas from the literature and in reviewing these in his monograph observed that many were not well differentiated from carcinoma and only a few could be considered as true primary sarcomas. Hickey and Simpson (3) reported two chondromas of the lung and reviewed 40 cases. Other authors (4) emphasize the great infrequency of the primary tumors of the lung and pleura. Kaufmann (5) describes the occurrence of small chondromas but considers malignant tumors such as spindle-cell, or small or mixed cell sarcoma, as very rare primary growths. He also points out, as has been our experience, that it is difficult to recognize their origin, whether from the lung or from the pleura. He considers primary tumors of the pleura as rare, reporting one large sarcoma in a woman. He quotes Mehrdorf, who described a huge fibrosarcoma which filled the right pleural cavity of a woman 42 years of age. Adler, Ewing (6), and Kaufmann emphasize the necessity of careful study of various portions of lung tumor and their metastases to determine their mesoblastic origin. It is needless to point out that a thorough search for growths elsewhere in the body is necessary before one may assume a tumor to be primary in the lung or pleura. Ewing further suggests that histologic appearances, which inflammatory lesions such as abscesses, tuberculosis, and syphilis may assume, might readily be mistaken for primary round cell and spindle-cell sarcomas. Again, many observers have shown that in the lung primary carcinomas may reveal areas of spindle-cells and round cells which represent typical carcinoma cells and not sarcoma.

In the following report five tumors are described — one chondroma, two fibromas, one fibromyoma, and one fibrosarcoma— primary in the lung or pleura, all of which from their gross and microscopic appearances are without doubt of neoplastic nature, and of connective tissue origin. All have been observed since 1925. The chondroma, which was small and found in the

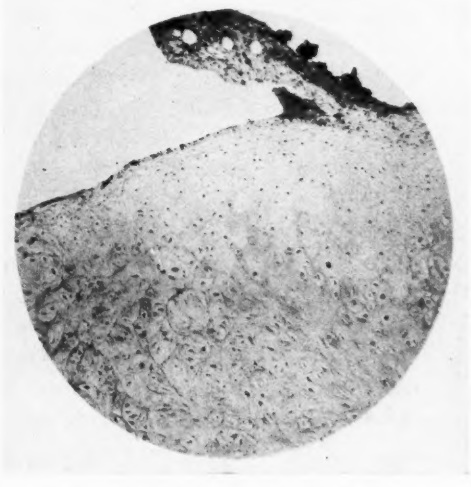


Fig. 1. Chondroma of the lung (Case 1).

[1]Read before the Radiological Society of North America, at the Fourteenth Annual Meeting, at Chicago, Dec. 3–7, 1928.

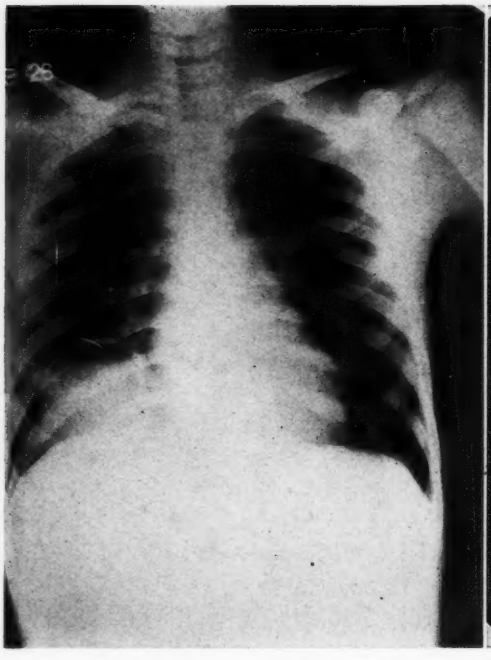


Fig. 2. Fibroma of the lung (Case 2).

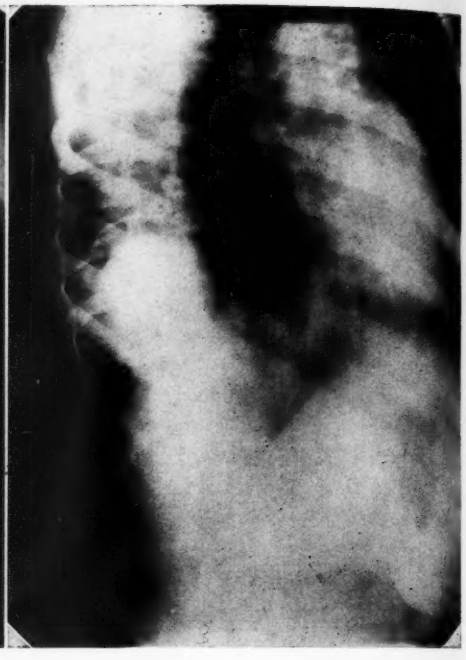


Fig. 3. Fibroma of the lung (Case 2). Oblique view.

routine of the autopsy, gave no clinical symptoms.

Case 1. Chondroma of the lung (from the Research and Educational Hospital of the University of Illinois College of Medicine; autopsy by Dr. R. H. Jaffe). Male, 41, white, had an acute perforation of a chronic duodenal ulcer, with a recent acute fibrino-purulent peritonitis. In the center of the lower lobe of the left lung, a nodule 7 mm. by 4 mm. by 3 mm. was found, which, on section, appeared white, homogeneous, and elastic like cartilage. In microscopic sections stained with hemotoxylin and eosin the tumor (Fig. 1) was found to consist of a blue-staining basement substance in which were embedded large cells with small indented dark nuclei. The protoplasm stained a deep red and contained frequent large vacuoles. The entire mass was surrounded by a capsule of dense connective tissue. Near the capsule, but not attached to it, there was a small bronchus. Associated with these findings were a healed tuberculosis of the apex of the right lung, purulent intrahepatic cholangitis, pylephlebitis, lobular pneumonia of both lower lobes, chronic splenitis, chronic gastritis and cholecystitis, and cloudy swelling of the kidneys.

Case 2. Fibroma of the lung (Lutheran Memorial Hospital). The patient, a boy, 15, white, entered complaining of pain in the right side under the ribs and in the lumbar region. The symptoms followed an accident five months previously when he was thrown from a toboggan against a tree. He subsequently coughed up small quantities of blood, and had considerable pain for a week. The pain abated somewhat and he expectorated small amounts of blood occasionally. He felt indisposed the entire period following the accident. Upon examination, dullness, increased tactile and vocal fremitus, and a few expiratory râles were

Fig. 4. Fibroma of the lung (Case 2). Note the numerous and fairly large blood vessels.

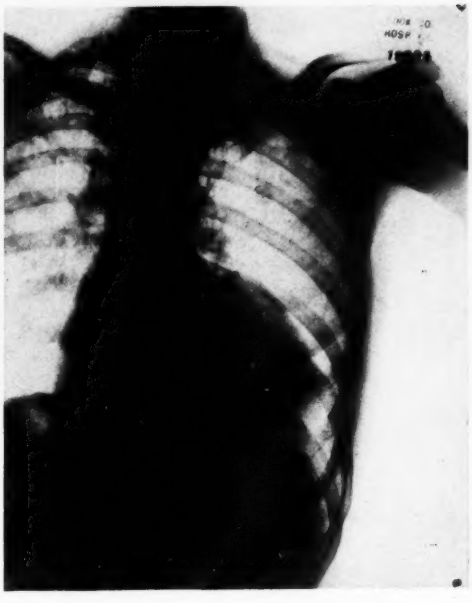


Fig. 5. Fibroma of the lung or pleura. Most of the tumor lies behind the heart and only the left border is visible.

noted over the right lower lobe. Laboratory findings were of no significance except possibly a leukocyte count that varied from 9,200 to 13,400. Of great interest was the roentgenogram of the chest as reported by Dr. R. Householder. The chest was symmetrical, well developed, and the expansion was good. The heart and mediastinal shadows were normal in size and position. The hilum was moderately prominent, with considerable fibrosis and a few small dense glands and calcified areas up to and about 8 mm. in diameter. The linear markings were also prominent; the apices were clear; on the right side in the posterior and lower portion there was a very sharply defined, well circumscribed, slightly oval, annular shadow (Figs. 2 and 3) about 9 cm. by 7.5 cm. The lower border of the shadow extended downward into the posterior costophrenic sinus so that the lower margin was about 2 cm. below the dome of the diaphragm. The upper border was on the level of the eighth rib posteriorly, the lateral border 2 cm. from the lateral chest wall. The area was dense and homogeneous except for a clear area at the upper border, transversely about 5.5 cm. and 1 cm. in height. This did not vary with change of posture from the upright to the horizontal position. The entire area was surrounded by a well defined capsule about 1 to 2 mm. thick. There were no radiating lines from this into the adjacent lung tissue. Fluoroscopic examination of the gastro-intestinal tract revealed no findings of a diaphragmatic hernia. A clinical diagnosis of lung tumor was made and surgical measures were carried out in multiple stages. One day after the last operation the patient died, apparently from shock and hemorrhage. Autopsy was refused.

At the last operation the tumor was seen on the posterior surface of the lower lobe, darker than the surrounding tissues and of firm consistency. The growth appeared well encapsuled yet could not be removed in one mass, but in several pieces, which in places were soft and friable. The tissue presented a mottled surface, with red,

Fig. 6. Fibroma of the lung or pleura, adherent to lung by broad pedicle of fibrous tissue (Case 3).

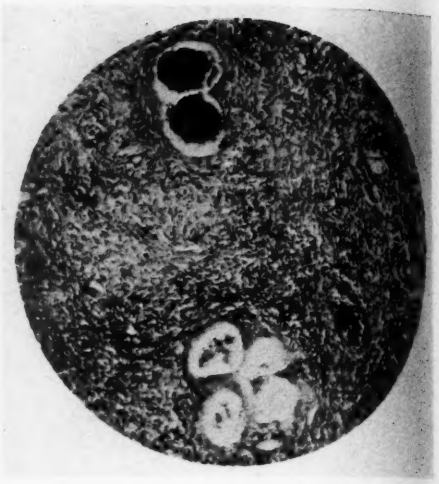


Fig. 7. Fibroma of the lung or pleura (Case 3).

white, and yellow areas. The portion with the capsule had a smooth surface, of white color, less vascular, and had no communication with the bronchi.

Microscopic examination (Fig. 4) revealed large areas of necrosis which stained poorly and corresponded to the yellow portions. The white areas showed typical interlacing bundles of spindle cells and collagen fibers as seen in a fibroma. The blood vessels were quite numerous, their walls thin and lumens often thrombosed. The bundles were rather loose, and the collagen fibers separated by clear areas representing fluid. The nuclei varied from flat to round forms; the greater number, however, were of oval outline, regular in staining quality, and showed no mitoses. In the region of necrotic areas were seen many lymphocytes and moderate numbers of polynuclear leukocytes. The capillaries were often dilated and engorged with erythrocytes. There were occasional areas of recent and old hemorrhage, the latter revealing pigment deposits and pink areas infiltrated with fibroblasts. Some areas contained large numbers of dilated capillaries and small vessels separated only by a loose spindle-cell stroma.

Several points of interest should be noted in this case. The relationship of the injury to the tumor is doubtful. The tumor may have existed before the injury and the trauma may have caused hemorrhage into the growth. The X-ray and surgical findings indicated a well-defined growth of a benign type. The microscopic picture likewise appeared benign, but the unusual features were the great vascularity, the necrosis, which may have been due to comparatively rapid growth or to the pecularities that seem to be constant in other pulmonary growths we have observed.

Case 3. Fibromyoma of lung or pleura. Male, white, 33, entered the Cook County Hospital in a stuporous state and died one week later. No history could be obtained. Upon examination the patient appeared emaciated, and showed moderate rigidity of the neck, positive Brudzinski and Kernig signs. The chest revealed râles over both

Fig. 8. Fibromyoma of lung or pleura (Case 4). Note the dark, irregular areas which are due to old and recent hemorrhages.

Fig. 9. Fibromyoma of lung or pleura (Case 4).

apices. Spinal puncture was made and an opalescent fluid, under pressure, was obtained. The cell count was 630 per cmm., mostly lymphocytes. Pandy was positive; Wassermann negative; hemoglobin 70 per cent; leukocyte count 12,350; blood Wassermann 4 plus positive. The temperature varied from 101 to 104° F. In an anteroposterior view in the X-ray an ulcerative pulmonary tuberculosis was obvious in both upper lobes, and about the heart an additional shadow of the structure lying behind the anterior, with a sharp, well defined margin (Fig. 5). No other observations were made because of the poor condition of the patient. A clinical diagnosis of pulmonary tuberculosis and tuberculous meningitis was made. The anatomical diagnosis from the autopsy was as follows (Dr. R. H. Jaffe): Tuberculous exudative and miliary leptomeningitis; chronic ulcerative tuberculosis of both upper pulmonary lobes; healed tuberculosis (primary) of the right lower pulmonary lobe; brown atrophy of the heart and liver; passive congestion of the liver, kidneys, and spleen; empyema of the appendix, with regional lymphadenitis; fibroma of the pleura of the right upper and median pulmonary lobes; fibrous adhesions about both lungs; decreased lipoid content of the adrenal glands; early syphilitic aortitis; fibrous adhesions about the spleen; marked distention of the stomach and urinary bladder; moderate emaciation and dehydration.

The tumor was found to be attached to the lower part of the margin of the upper lobe, and to the upper anterior portion of the middle lobe (Fig. 6). It consisted of a well-circumscribed mass which bulged into the anterior mediastinum and covered the right half of the pericardial sac. The growth was somewhat oval and firm, surrounded by a smooth capsule containing prominent and injected blood vessels. It measured 13.5 cm. vertically, 7 cm. anteroposteriorly, and 11.5 cm. transversely. The cut surface was smooth, chiefly white, mottled with gray and red areas. The mass was firmly attached to the lung by adhesions

Fig. 10. Huge fibrosarcoma of lung or pleura (Case 5).

formed by dense bands of connective tissue. Upon histologic examination (Fig. 7) the tumor was found to be composed of trabeculæ of collagenous tissue interspersed with elongated nuclei showing finely granular chromatin network. In places the nuclei were quite numerous but they were regular in shape and mitoses were absent. Most areas of the mass were very vascular, the vessels as a rule being variable in size, their walls uniformly thin, and their lumens often engorged with erythrocytes. One large vessel deep in the tumor had a thickened wall undergoing hyaline degeneration in the median coat. The capsule measured 1 to 3 mm. in thickness and consisted of dense fibrous tissue containing few nuclei. In some parts the tissue was loose, the collagen fibers separated, and the nuclei less dense. In such areas islands of hyaline change were often present.

Like the previous fibroma, this tumor was very vascular, showed none of the extensive necrosis, but, instead, considerable hyaline degeneration. The origin was doubtful—either pleural or pulmonary.

When the chest roentgenogram was reported, the shadow was at first interpreted as an enlarged heart to the left, but closer subsequent study revealed the outline of the heart to be independent of the less dense shadow that lay behind and to the left of the cardiac density.

Case 4. Fibromyoma of the lung or pleura (Lutheran Memorial Hospital). Male, 65, white, was brought to the hospital because of injuries. Upon examination several fractured ribs were found, together with a hemothorax. Urine and spinal fluid were normal. Blood count: 37 per cent hemoglobin; 2,008,000 erythrocytes; 36,200 leukocytes, with 92 per cent polynuclears, 8 per cent lymphocytes. The findings at autopsy were: carcinoma of stomach; old healed gastro-jejunostomy; large white kidneys; fatty changes in the liver; atheromata of aorta and aortic leaflets; fractured ribs; hypertrophy of left ventricle of heart. The left pleural cavity was filled with blood and the lung atelectatic from compression. The apex revealed a healed scar, together with fibrous adhesions. From the left pleural cavity a tumor was readily shelled out from the surrounding tissue. The mass (Fig. 8) was of oval outline, measuring 12 by 6 by 5 cm.; very firm in consistency and on section revealed interlacing bundles of white and gray tissue, with scattered areas of old and recent hemorrhage. The surface was smooth and revealed numerous vessels of varying sizes; the surrounding adhesions consisted of loose fibrous tissue. Upon histologic examination (Fig. 9) the tissue was found to be made up of bundles of spindle cells consisting of collagen fibers and smooth muscle tissue, interlaced in all directions. The tissue was predominantly fibrous tissue, with occasional bundles of smooth muscle cells. On the whole, there

were considerable areas of collagen fibers, and only a few loose edematous areas. The cells were regular, with nuclei, mostly oval or flat, and regular in outline and in staining qualities. Blood vessels in these areas were moderate in numbers, but in the degenerated portion appeared very numerous, dilated, and often thrombosed. The degenerating areas revealed poorly staining spindle cells and numerous round cells and polynuclears. Some areas appeared to be entirely necrotic and about these areas the smaller as well as the larger vessels were entirely thrombosed.

In this case, as in Case 3, the origin of the tumor was doubtful. The cellular elements might arise from either lung or pleura.

Case 5. Fibrosarcoma of the lung or pleura (Lutheran Deaconess Hospital). Female, white, nurse, 52 years old, complained of dyspnea, pain and swelling in both upper and lower extremities. Her illness began about eighteen months before admission, at which time her ankles became painful and swollen. This continued, and in the course of six months her knees and hips also became involved. At this time she entered the hospital and in the course of the routine examination a tumor mass was discovered in the left thoracic cavity. No symptoms referable to the chest were observed until four months later, when she began to have a sensation of pressure in the center of the chest, and considerable cough. About this time the fingers, wrists, and later her elbows and shoulders became swollen and painful. Cough had been persistent and non-productive during the past few months. Since the onset of the disease she had lost about twenty pounds.

The physical examination revealed dullness to flatness, with absent breath sounds and greatly decreased tactile and vocal fremitus throughout the lower part of the left chest. The heart was markedly displaced to the right. The fingers, toes, wrists, ankles, elbows, and knees showed typical clubbing and swelling of hypertrophic pulmonary pseudo-osteoarthropathy. The veins over the front of the thorax were markedly dilated; arteries very prominent and visibly pulsating. The temperature varied from 99 to 100° F.; pulse 110; respiration 20. The Wassermann was negative; leukocytes 7,150; hemoglobin 85 per cent; differential, normal.

Fig. 11. Hypertrophic pseudo-osteoarthropathy associated with fibrosarcoma of lung or pleura (Case 5).

The roentgenogram showed little or no movement of the left thorax; the heart was markedly displaced; on the left side there was a large, homogeneous, dense mass about 15 cm. in diameter, sharply circumscribed, occupying the lower portion of the left lung field up to the level of the fifth rib posteriorly and the second rib anteriorly (Fig. 10). Roentgenograms of the upper and lower extremities showed clubbing of fingers and

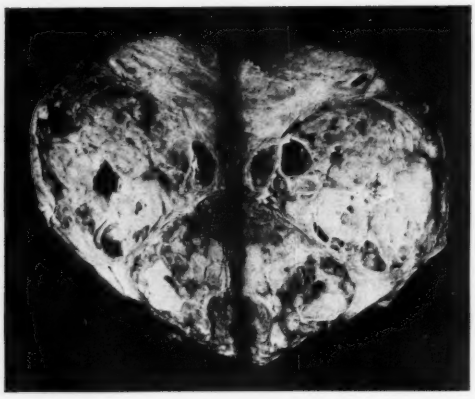


Fig. 12. Fibrosarcoma of lung or pleura (Case 5). Note the areas of necrosis, hemorrhage, and cystic degeneration.

toes and the hyperplastic periostitis typical of pulmonary pseudo-osteoarthropathy (Fig. 11).

The patient was operated on by Dr. C. A. Hedblom. The white fibrous wall of the tumor was observed to move visibly to and fro; there was no tendency for it to fall away from the chest wall. A small piece was excised for histologic examination. The patient recovered from the operation, left the hospital, and died at her home four months later.

At autopsy the findings were: Huge fibrosarcoma of the left pleura or lung; compression pulmonary atelectasis (left); compensatory emphysema of right lobes; brown atrophy of the heart; fatty changes in the liver; atrophy of spleen; edema of the legs; hypertrophic pseudo-osteoarthropathy of the extremities; emaciation.

The tumor mass in the left chest was spherical, 18 cm. in diameter, very firm, and readily removed from the pleura by breaking the fibrous adhesions about the capsule. To free it entirely it was necessary to tear the lung tissue over an area 3 cm. in diameter in the lower lobe of the atelectatic lung. The left lung was extremely small and collapsed. The right was markedly emphysematous. No metastases were demonstrable in the mediastinal lymph glands or in any viscera.

The tumor (Fig. 12) had a fairly smooth

Fig. 13. Fibrosarcoma of lung or pleura (Case 5).

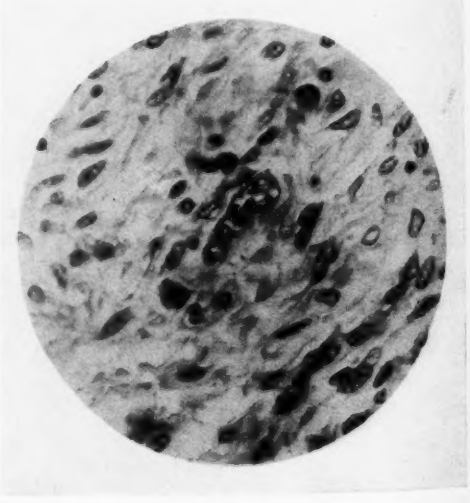


Fig. 14. Anaplasia of nuclei in fibrosarcoma (Case 5).

surface, traversed by large, prominent blood vessels. On section, the surface was found to be largely white and gray and mottled, with many areas of recent and old hemorrhages. A few soft yellow areas of necrosis and of cystic degeneration were present. Histologic examinations (Fig. 13) were made of many areas; in some, the appearance was identical with Case 2, like that of a fibroma, but in other portions the cells were large, spindle-shaped, and the nuclei distinctly anaplastic (Fig. 14). Many portions were entirely necrotic and others were undergoing degeneration. In the region of necrotic areas numerous round cells and polynuclears were seen. The vessels in such regions were, as a rule, thrombosed. The blood vessels were very numerous, with rather thin walls, and often filled with erythrocytes. A few areas revealed considerable numbers of collagen fibers and relatively few nuclear elements, but most of the sections from different portions were richly cellular—in some places as compact masses of cells, in others very loosely arranged.

Microscopic sections of both lungs, liver, spleen, peribronchial lymph glands, adrenals, and kidney revealed no metastases. The peribronchial lymph glands were markedly fibrosed and anthracotic. In the liver, spleen, kidney, and lung there was a moderate degree of passive congestion. Section through the attached portion of the lung showed atelectatic lung tissue, with no invasion of spindle cells into the pulmonary structure. There were numerous foci of round cells infiltrating the interstitial septa. In the opposite lung the alveoli were large, and scattered groups showed distinct early bronchopneumonia, with engorgement of blood vessels and exudation of polynuclears and erythrocytes into the acini.

The tumor in this patient histologically appeared to be a fibrosarcoma, growing to tremendous size and causing local symptoms of obstruction and general symptoms from absorption. The remarkable finding was the complete absence of demonstrable metastases, a finding which would indicate that, if observed earlier, the tumor could have been removed by surgical operation.

Ewing refers to a large spindle-cell sarcoma, not unlike this tumor, in which the tumor becomes very bulky, exceeding in size the largest carcinomas. He also refers to the necrosis, cystic changes and hemorrhages that may occur in these tumors.

## SUMMARY

1. Five mesenchymatous tumors are reported—one chondroma, two fibromas, one fibromyoma, and one fibrosarcoma.

2. With the exception of the chondroma, these tumors are highly vascular, and show great tendency to hemorrhage and necrosis.

3. In three cases, the tumors lie almost free in the pleural cavity and, in spite of autopsy and histologic examination, the origin could not be exactly determined as being primary from the lung or from the pleura.

4. From the locations and the well-defined capsules, the tumors should be considered as removable by surgical operation.

5. Our observations would seem to indicate that, like primary carcinomas of the lung, primary mesenchymatous tumors may be increasing in frequency.

## BIBLIOGRAPHY

(1) Delafield, F., and Prudden, T. M.: Textbook of Pathology, 14th Edition, 1927, p. 731.

(2) Adler, I.: Primary Malignant Growths of the Lungs and Bronchi, 1912.

(3) Hickey, P. M., and Simpson, W. M.: Primary Chondroma of Lung. Acta Radiologica, 1926, V, 475-500.

(4) Wessler, H., and Jaches, L.: Clinical Roentgenology of Diseases of the Chest, 1923, pp. 293 and 388.

(5) Kaufmann, E.: Pathology; translation by S. P. Reimann, 1929, Vol. I.

(6) Ewing, J.: Neoplastic Tumors, 1922.

DISCUSSION

DR. E. L. JENKINSON (Chicago): I would like to ask Dr. Pilot if any of these cases showed any definite or characteristic evidence in the X-ray that might lead to diagnosis.

DR. I. PILOT (closing): In response to Dr. Jenkinson's question, as to how to diagnose tumors of tissue origin, I wish to say that I do not believe a diagnosis can be made, strictly speaking, from just the radiological observation; I think it is important to make a thorough clinical and laboratory study in addition to the radiological study. One point is important, and that is the repeated radiographic study of the chest, in order to watch the progress of the case. About a year ago we observed a case in which apparently a tumor mass had been discovered accidentally in the routine examination. We kept the man in the hospital for four months and the tumor mass was exactly the same size as when he first came in and had given no symptoms, and we permitted him to leave. I feel that some of the cases that Dr. Farrell refers to, which have responded so well, or apparently so well, to X-ray therapy, are more likely tumors of connective tissue origin than carcinoma. The other case referred to is certainly one for which the Doctor should be congratulated, because it appears to be identical with that last case we showed, namely, a huge fibrosarcoma which had a pedicle about three centimeters in diameter and which might have been cured by surgical operation.

# DETERMINATION OF RADIATION VALUES IN LUNG TISSUE WITH VARIABLE QUALITIES OF RADIATION[1]

By J. L. WEATHERWAX, M.A., and CHARLES ROBB, E.E., Radiological Department, Philadelphia General Hospital, and Graduate School of Medicine, University of Pennsylvania, PHILADELPHIA

IN the use of high voltage roentgen-ray therapy, the question often arises in the minds of radiologists as to the depth dose of radiation given to lung tissue. What effect does the reduced density of lung tissue, with air cavities, have on the absorption and scattering of radiation?

There have been no published data in the United States bearing on this subject, except a discussion of Duane's paper on "Measurement of Dosage by Means of Small Ionization Chambers," by Glasser (1). In this discussion, Glasser gave data of ionization measurements made in water with the top of a small rectangular air cavity placed, first, near the surface in a water phantom, with the ionization chamber in the center of the field of radiation underneath the water phantom. The measurement of the intensity at this point was called 100 per cent. In the second position the top of the air cavity was moved one-fourth of the depth of the phantom from the surface of the water. With the ionization chamber in the same position, the measured intensity was 92 per cent of the intensity in Position Number 1. In the third position, the top of the air cavity was placed one-half the depth of the water phantom from the surface. Ionization measurements of the intensity at this point showed it to be 86 per cent of the intensity when the air cavity was in Position Number 1. In the last and fourth position, the air cavity was placed on the bottom of the water phantom directly above the ionization chamber. Ionization measurements of the intensity at this point proved it to be 79 per cent of the intensity with the air cavity in Position Number 1.

TABLE I. RELATIVE INTENSITY MEASUREMENTS OF RADIATION IN A WATER PHANTOM WITH VARIABLE COPPER FILTERS

| Depth (in cm.) | Relative Intensity in Water Phantom with Variable Filters (in mm.) | | | | | |
|---|---|---|---|---|---|---|
| | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. |
| Surface | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1 | 102.2 | 101.6 | 101.6 | 102.0 | 101.5 | 101.8 |
| 2 | 95.8 | 98.0 | 98.6 | 99.0 | 99.6 | 99.6 |
| 3 | 86.3 | 89.2 | 90.4 | 91.4 | 92.0 | 92.5 |
| 5 | 70.2 | 73.9 | 74.4 | 75.4 | 76.2 | 77.0 |
| 7 | 56.2 | 58.8 | 59.8 | 61.0 | 61.8 | 62.8 |
| 10 | 37.9 | 42.0 | 43.8 | 44.4 | 45.2 | 46.2 |
| 12 | 28.6 | 32.2 | 33.6 | 35.0 | 36.2 | 36.6 |
| 15 | 17.8 | 20.4 | 21.8 | 23.0 | 23.6 | 24.0 |
| 18 | 10.7 | 12.8 | 13.8 | 14.6 | 15.2 | 15.8 |
| 20 | 8.1 | 9.6 | 10.6 | 11.5 | 11.8 | 12.6 |

It is seen that by moving the air space from the surface of the water phantom to the bottom, there was a reduction in the quantity of radiation reaching the ionization chamber. There was a gradual reduction from the surface to the bottom of the water phantom, due to a change of the scattering conditions.

The above experiment does not reproduce lung conditions: the lung is not moved about as is the air cavity. We wished to reproduce as nearly as possible conditions analogous to those in the instance of the treated patient. With this object we obtained a lung, so removed at autopsy as to enable us to connect it to an air system and

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

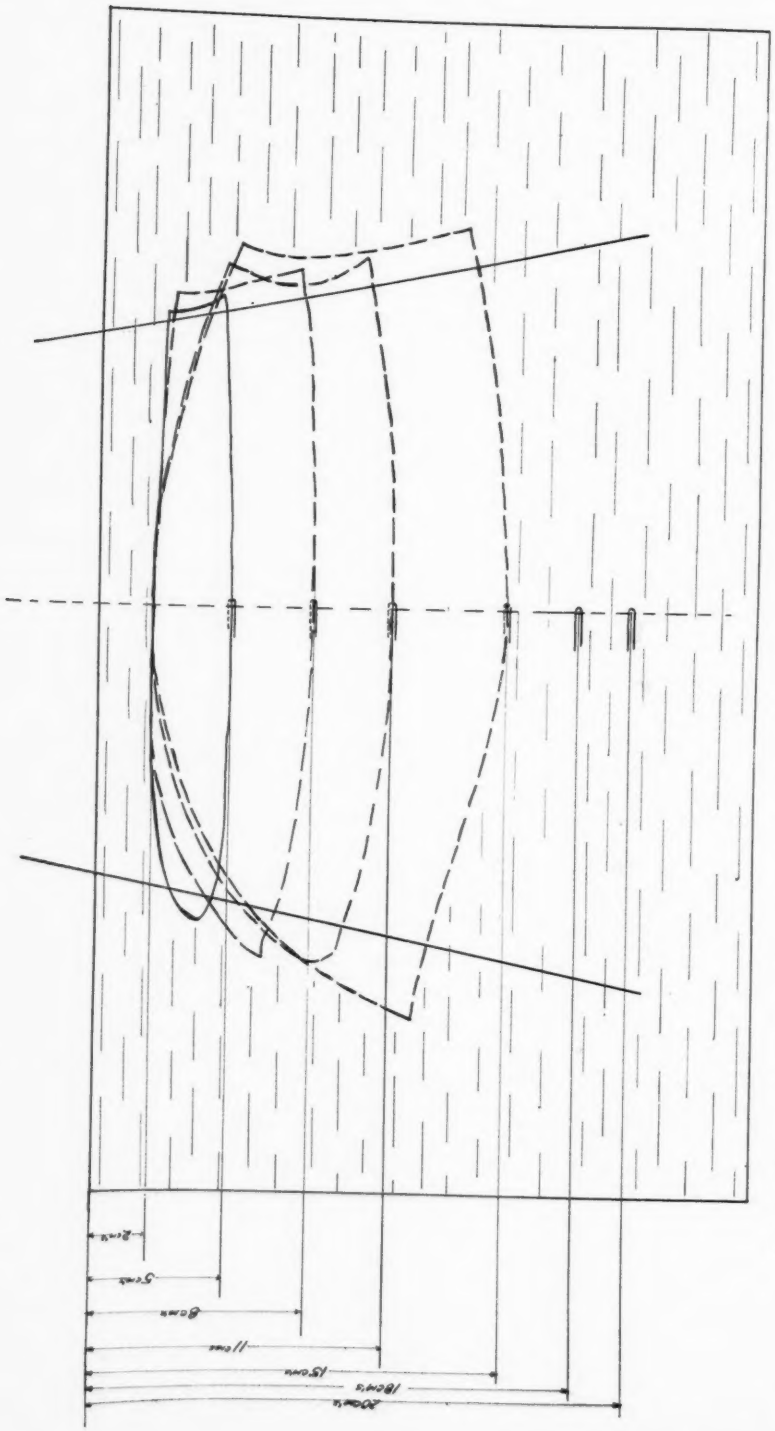


Fig. 1. Diagram showing various degrees of inflation of lung, with positions of ionization chamber.

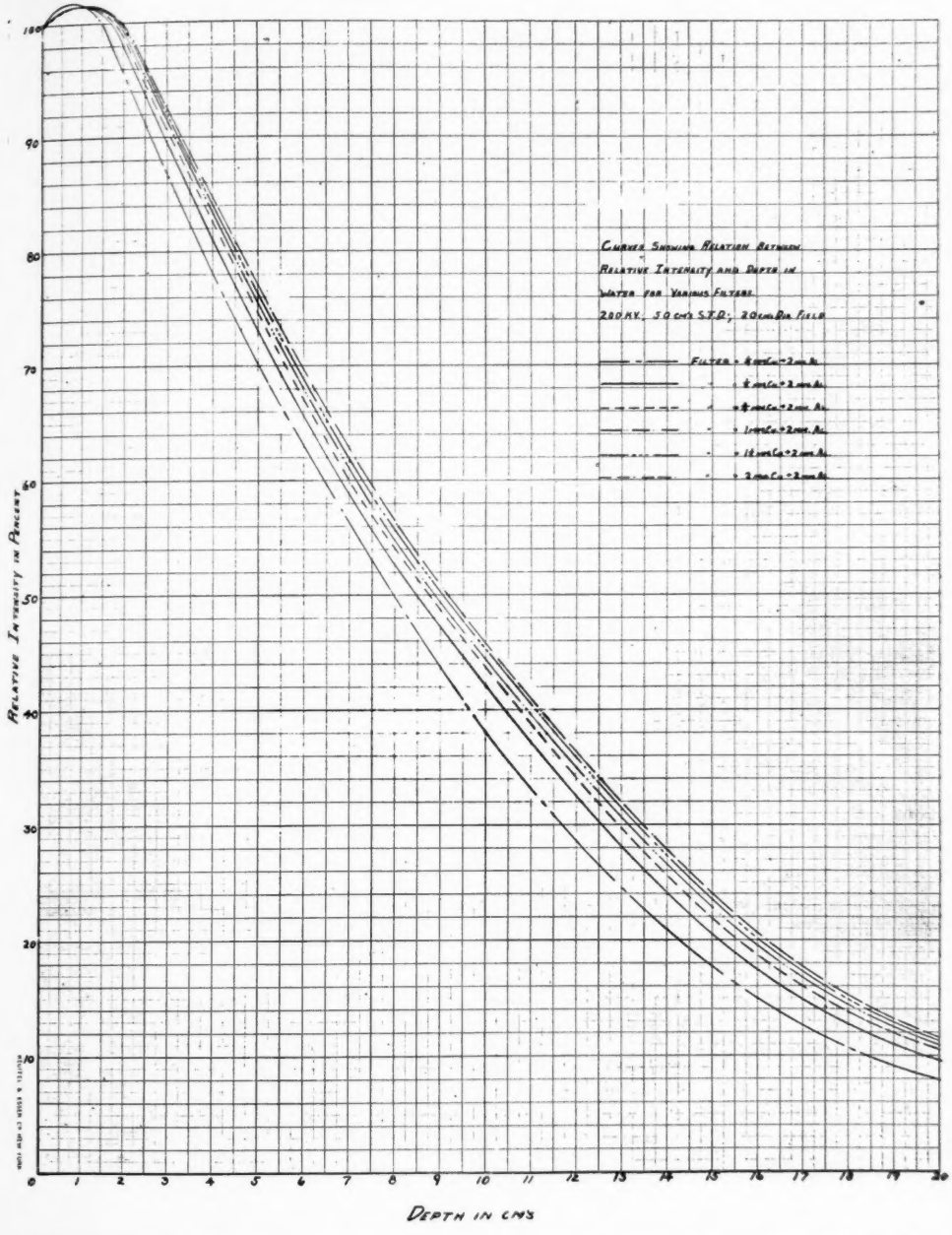

Curves Showing Relation Between
Relative Intensity and Depth in
Water for Various Filters
200 KV. 50 cms S.T.D.; 20 cms Dia Field
Filter = ¼ mm Cu + 2 mm Al
Relative Intensity in Percent
Depth in cms

Fig. 2. Relative intensity of radiation in a water phantom with variable filters of copper (200 K.V., 50 cm. S.T.D., 20 cm. diam. of field). Curves, reading from below upward: —— — —— filter is ¼ mm. Cu. + 2 mm. Al.; ——— filter is ½ mm. Cu. + 2 mm. Al.; — — — — filter is ¾ mm. Cu. + 2 mm. Al.; — · — filter is 1 mm. Cu. + 2 mm. Al.; — - - - — filter is 1½ mm. Cu. + 2 mm. Al.; — — · — — filter is 2 mm. Cu. + 2 mm. Al.

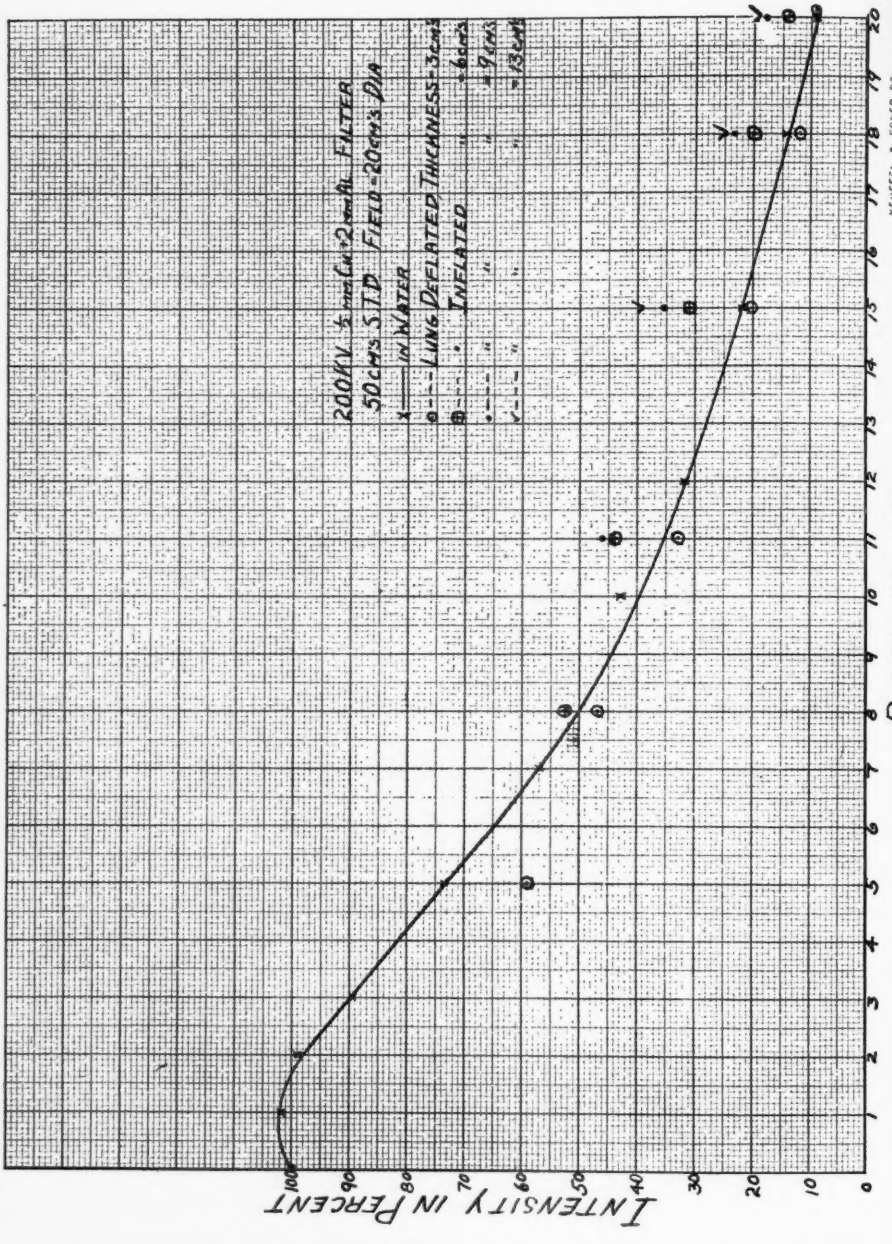

200KV ½ mm Cu + 2 mm Al FILTER
50 cms S.T.D FIELD = 20 cms DIA
x —— IN WATER
o - - - LUNG DEFLATED THICKNESS = 3 cms
B . . . . " INFLATED " " = 6 cms
• . . . " " " " = 9 cms
v - - - " " " " = 13 cms
INTENSITY IN PERCENT
DEPTH IN CMS
KEUFFEL & ESSER CO

Fig. 3. Relative intensity values obtained for a filter of ½ mm. Cu. + 2 mm. Al. for different lung inflations, compared to a relative intensity curve for water.

maintain any desired inflation. The lung, connected to the air system, was immersed in a water phantom two centimeters below the surface of the water, the top of the lung always remaining two centimeters from the surface of the water, the expansion being mostly downwards and to some degree outwards.

Ionization measurements were made with the lung in the following states of expansion:

(1) Relative intensity measurements

were made through 2 cm. of water and 3 cm. of lung tissue in a state of collapse at atmospheric pressure, obtaining measurements of the radiation at various depths in the water beneath the lung up to 20 centimeters.

(2) The lung was first expanded from a thickness of 3 cm. to a thickness of 6 cm. Ionization measurements were made at the surface of the water directly underneath the lung, and on up to a depth of 20 centimeters.

(3) The lung was further expanded to a thickness of 9 cm. and 13 cm., respectively, and relative intensity measurements were made on the surface of the water, underneath the lung, and up to a depth of 20 centimeters. The different positions of the lung and the ionization chamber are shown in Figure 1.

Throughout all the measurements, the technic was as follows: 200 K.V. (peak), 5 ma., 2 mm. aluminum, 50 cm. S.T.D. and a field 20 cm. in diameter. The copper filter was varied.

In order to compare relative intensity measurements through lung tissue, we have shown, in Figure 2, curves representing the loss of radiation intensity in water for additional filters of copper varying from ¼ mm. copper to 2 mm. copper.

The ionization chamber was placed in the center of the field of radiation, a horn ionization chamber similar to the Friedrich and Kroenig type of about 1 cubic centimeter capacity being used. An electroscopic system was used to measure the ionization current (2) (3).

Table I gives the percentages of relative intensity data, with corresponding positions of the ionization chamber in the water phantom, from which the curves were plotted.

The lung was immersed in the water phantom to a depth of two centimeters, being spread over practically the entire field of radiation. Ionization measurements of the radiation were obtained with the ionization chamber half submerged in water in the center of the field of radiation, which con-

TABLE II. RELATIVE INTENSITIES AT DIFFERENT LUNG PRESSURES WITH VARIABLE FILTERS

| Depth (in cm.) | Lung Deflated Thickness=3 cm. | | | | | | Lung Inflated Thickness=6 cm. | | | | | | Lung Inflated Thickness=9 cm. | | | | | | Lung Inflated Thickness=13 cm. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. |
| Surface | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 5 | 55.0 | 58.9 | 60.0 | 61.2 | 62.2 | 63.8 | | | | | | | | | | | | | | | | | | |
| 8 | 44.5 | 47.1 | 47.4 | 47.8 | 48.4 | 49.2 | 50.8 | 52.4 | 52.8 | 53.3 | 55.6 | 58.1 | | | | | | | | | | | | |
| 11 | 31.8 | 33.2 | 33.3 | 34.7 | 35.3 | 35.5 | 41.8 | 44.5 | 44.8 | 45.1 | 46.0 | 47.4 | 45.0 | 46.0 | 46.5 | 46.8 | 47.2 | 48.0 | | | | | | |
| 15 | 17.7 | 19.6 | 20.0 | 20.8 | 22.4 | 22.7 | 25.4 | 27.0 | 28.2 | 29.9 | 30.6 | 32.9 | 35.9 | 35.9 | 36.0 | 36.6 | 37.2 | 38.4 | 37.2 | 39.5 | 41.1 | 42.1 | 42.9 | 44.2 |
| 18 | 10.8 | 12.6 | 13.9 | 14.1 | 15.4 | 14.1 | 17.9 | 19.7 | 21.0 | 21.5 | 22.0 | 22.2 | 20.8 | 23.2 | 24.2 | 25.0 | 26.2 | 27.4 | 22.7 | 24.6 | 25.4 | 26.4 | 28.1 | 28.5 |
| 20 | 7.8 | 9.3 | 9.3 | 10.0 | 10.7 | 10.7 | 12.3 | 14.0 | 15.0 | 15.8 | 16.1 | 17.5 | 16.1 | 17.8 | 19.4 | 19.8 | 20.8 | 21.1 | 16.7 | 19.1 | 19.8 | 20.5 | 20.8 | 21.1 |

Fig. 3. Relative intensity values obtained for a filter of ½ mm. Cu. + 2 mm. Al. for different lung inflations, compared to a relative intensity curve for water.

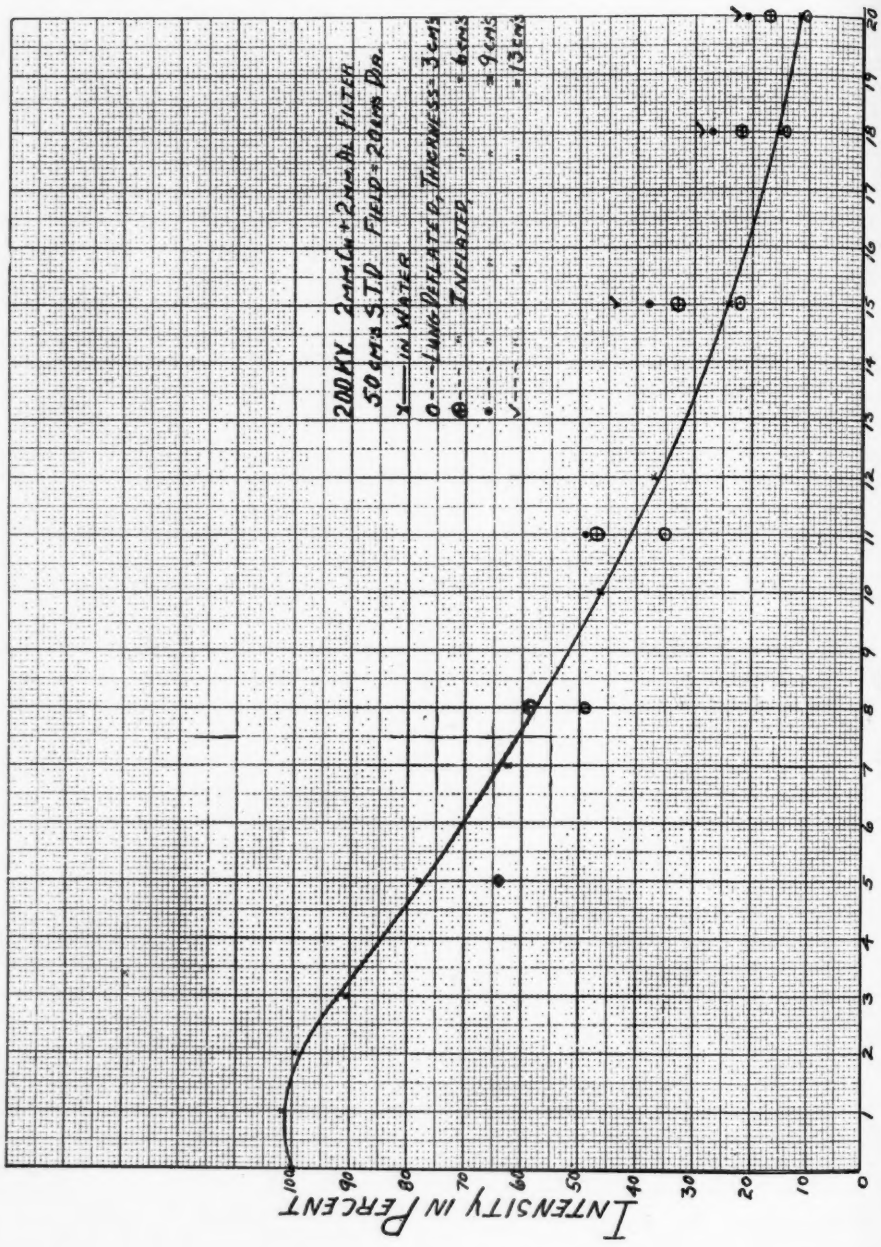

200 KV. 2 mm Cu + 2 mm Al. FILTER
50 cms S.T.D. FIELD = 20 cms Dia.
x ——— IN WATER
o - - - LUNG DEFLATED, THICKNESS = 3 cms
⊕ - - - " " = 6 cms
• - - - " " = 9 cms
v - - - " " = 13 cms
INTENSITY IN PERCENT
DEPTH IN CM'S
KEUFFEL & ESSER CO

Fig. 4. Relative intensity values for a filter of 2 mm. Cu. + 2 mm. Al. for different lung inflations compared to the relative intensity curve for water.

stituted the surface intensity and were designated as 100 per cent. The ionization chamber was next placed underneath the lung in contact with the tissue, and a measure of the radiation intensity at this point was obtained. The ionization chamber was moved down in the water beneath the lung and readings of the radiation intensity taken in steps of 3 cm. change in depth to a total depth of 20 centimeters. This procedure was followed for each different lung inflation.

Figure 3 shows the relative intensity values obtained for a filter of ½ mm. Cu. plus 2 mm. Al. for different lung inflations, compared to a relative intensity curve for water.

Figure 4 shows the relative intensity values for a filter of 2 mm. copper and 2 mm. aluminum for different lung inflations, compared to the relative intensity curve for water.

Filters of ¼, ¾, 1, and 1½ mm. of Cu. plus 2 mm. Al. gave relative intensity curves for different lung inflations similar to those shown in Figures 3 and 4.

The relative measurements for various depths in water with different filters and lung inflations are shown in Table II.

Table III gives relative intensity measurements for water, and water and lung (at different states of inflation) for ¼, ½, and 2 mm. copper plus 2 mm. aluminum.

In comparing relative intensity measurements obtained through 2 cm. of water and lung tissue to the same depth in water, we found that:

(1) The intensity of radiation at 5 cm. in water alone is greater than the intensity at the same level through 2 cm. of water and 3 cm. of collapsed lung.

(2) A greater quantity of radiation passes through 2 cm. of water and inflated lung from 6 cm. to 13 cm.

TABLE III. COMPARATIVE RELATIVE INTENSITIES FOR WATER, AND FOR WATER AND LUNG TISSUE

| Depth (in cm.) | Relative Intensity in Water | | | Relative Intensity with Lung Submerged in Water Various Degrees of Inflation | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Thickness=3 cm. | | | Thickness=6 cm. | | | Thickness=9 cm. | | | Thickness=13 cm. | | | | |
| | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | 2 Cu. + 2 Al. | | |
| Surface | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | |
| 1 | 102.2 | 101.6 | 101.8 | | | | | | | | | | | | | | |
| 2 | 95.8 | 98.0 | 99.6 | | | | | | | | | | | | | | |
| 3 | 86.3 | 89.2 | 92.5 | | | | | | | | | | | | | | |
| 5 | 70.2 | 73.9 | 77.0 | 55.0 | 58.9 | 63.8 | | | | | | | | | | | |
| 7 | 56.2 | 58.8 | 62.8 | | | | | | | | | | | | | | |
| 8 | 49.8 | 52.6 | 56.5 | 44.5 | 47.1 | 49.2 | 50.8 | 52.4 | 58.1 | | | | | | | | |
| 10 | 37.9 | 42.0 | 46.2 | | | | | | | | | | | | | | |
| 11 | 33.1 | 37.1 | 41.0 | 31.8 | 33.2 | 35.5 | 41.8 | 44.5 | 47.4 | 45.0 | 46.0 | 48.0 | | | | | |
| 12 | 28.6 | 32.2 | 36.6 | | | | | | | | | | | | | | |
| 15 | 17.8 | 20.4 | 24.0 | 17.7 | 19.6 | 22.7 | 25.4 | 27.0 | 32.9 | 35.9 | 35.9 | 38.4 | 37.2 | 39.5 | 44.2 | | |
| 18 | 10.7 | 12.8 | 15.8 | 10.8 | 12.6 | 14.1 | 17.9 | 19.7 | 22.2 | 20.8 | 23.2 | 27.4 | 22.7 | 24.6 | 28.5 | | |
| 20 | 8.1 | 9.6 | 12.6 | 7.8 | 9.3 | 10.7 | 12.3 | 14.0 | 17.5 | 16.1 | 17.8 | 21.1 | 16.7 | 19.1 | 21.1 | | |

Fig. 4. Relative intensity values for a filter of 2 mm. Cu. + 2 mm. Al. for different lung inflations compared to the relative intensity curve for water.

TABLE IV. RELATIVE INTENSITY MEASUREMENTS OBTAINED THROUGH PARAFFIN WAX MOLDS CONTAINING AIR CAVITIES

| Depth (in cm.) | Mold No. 1, 370 c.c. of Air—6 cm. Thick, 1,340 Grams | | | | | | Mold No. 2, 428 c.c. of Air—8 cm. Thick, 1,770 Grams | | | | | | Mold No. 3, 470 c.c. of Air—13 cm. Thick, 3,090 Grams | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. | ¼ Cu. + 2 Al. | ½ Cu. + 2 Al. | ¾ Cu. + 2 Al. | 1 Cu. + 2 Al. | 1½ Cu. + 2 Al. | 2 Cu. + 2 Al. |
| Surface | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2 | 102.0 | 102.2 | 101.2 | 101.0 | 101.6 | 100.8 | 101.4 | 100.2 | 100.0 | 101.2 | 101.0 | 100.6 | 102.0 | 101.4 | 100.8 | 101.6 | 101.5 | 101.0 |
| 8 | 57.4 | 60.0 | 62.9 | 63.0 | 63.3 | 64.0 | | | | | | | | | | | | |
| 10 | 47.1 | 48.7 | 49.3 | 49.5 | 49.5 | 49.6 | 44.4 | 46.7 | 47.1 | 47.7 | 48.0 | 48.5 | | | | | | |
| 12 | 35.3 | 35.8 | 36.2 | 36.8 | 37.1 | 38.0 | | | | | | | | | | | | |
| 15 | 20.3 | 22.1 | 23.0 | 24.0 | 24.7 | 24.9 | 19.2 | 22.0 | 22.7 | 23.7 | 24.2 | 24.2 | 24.6 | 25.3 | 25.9 | 26.1 | 26.7 | 27.6 |
| 18 | 13.1 | 13.4 | 14.6 | 15.4 | 16.1 | 16.7 | 12.7 | 14.5 | 15.2 | 15.7 | 16.4 | 17.2 | 15.3 | 16.7 | 16.9 | 17.2 | 17.5 | 17.8 |
| 20 | 9.5 | 10.4 | 11.2 | 11.8 | 12.4 | 12.6 | 9.7 | 11.5 | 12.3 | 12.6 | 13.2 | 13.9 | 9.7 | 10.3 | 11.4 | 11.6 | 11.8 | 12.9 |

than through 8, 11, and 15 cm., respectively, of water alone.

We made tests of paraffin wax molds containing inflated finger cots, these air cavities being placed throughout the mold. We were interested in knowing whether the presence of air pockets in a denser and more homogeneous medium than lung tissue would give more or less radiation than measured in water.

The volume of air in the mold 6 cm. thick was about 1/5 of the total volume; in the mold 8 cm. thick about 2/11 of the total volume, and in the mold 13 cm. thick, about ⅛ of the total volume. A mold was immersed in a water phantom, keeping it 2 cm. from the surface of the water so as to duplicate, as nearly as possible, the previous arrangement of the lungs. Table IV gives the relative intensity measurements of radiation obtained with various filters and different sized molds.

There is practically no difference in the measurements obtained through the mold 6 cm. thick as compared to the mold 8 cm. thick. There is, however, 3 to 4 per cent greater radiation passing through the mold 13 cm. thick, and the relative intensity continues to increase as the ionization chamber is moved to a depth of 5 cm. in water beneath the molds. We realize that the relative intensity values of radiation obtained through wax molds containing air cavities are not comparable to relative intensity values of radiation obtained through lung tissue. The measurements show that, instead of getting a loss of radiation due to the air cavities, we are actually getting an increase.

## CONCLUSIONS

1. A collapsed lung reduces the measured radiation beneath 2 cm. of water and 3 cm. of lung tissue to a value below the radiation measured through 5 cm. of water, because there is less scattering in the lung tissue.

2. The measured radiation beneath 2 cm. of water and 6, 8, and 13 cm., respectively, of inflated lung tissue is greater than the measurements of radiation at the same levels in water alone, because there is less radiation being absorbed. The reduction of scattered radiation caused by the lung being filled with air is more than offset by the decreased stopping power of inflated lung tissue.

3. The isodose charts showing the relative intensity percentages in a water phantom are not high enough for lung tissue. The greatest thickness of inflated lung, 13 cm., approximates the average thickness of male and female through the third costal cartilage, according to Desjardins' anatomical charts of the average patient. The total thickness of the average male through this cross-section is 23 cm., and the thickness of the lung is 14.4 cm., while the total thickness of the average female through this cross-section is 22 cm., with a lung thickness at the greatest dimension of 14 centimeters.

## REFERENCES

(1) Glasser, Otto: Discussion of paper of William Duane, Ph.D., "Measurement of Dosage by Means of Ionization Chambers." Am. Jour. Roentgenol. and Rad. Ther., June, 1923, X, 493.

(2) Weatherwax, J. L., and Leddy, E. T.: Standardization of Ionization Measurements of Intensity and Measurements of Scattered and Secondary X-rays Effective in Producing an Erythema. Am. Jour. Roentgenol. and Rad. Ther., June, 1923, X, 488-492.

(3) Weatherwax, J. L., and Leddy, E. T.: Further Studies of Ionization Measurements of Roentgen-ray Intensity. Am. Jour. Roentgenol. and Rad. Ther., August, 1924, XII, 110-116.

## DISCUSSION

Dr. John T. Farrell, Jr. (Philadelphia): Any experiment enabling us to determine dosage more accurately is very important. However, there is probably no tissue in the body in which tumor changes are so various as the lungs. Oftentimes in carcinoma of the bronchus, the condition is one of simple infiltration, and there is going to be little or no effect from secondary radiation. On the other hand, some of these tumors go on to massive consolidation, and the amount of radiation reaching a particular point will be different when the tumor is solid than when it is of the infiltrative type. Now, between the infiltrative type on the one hand and the solid consolidation on the other, the lung picture in malignancy runs the gamut of all sorts of physical change. Therefore, I do not think that these physical measurements, based on study of the lung outside the body, can ever be quite as accurate as they are in the case of solid organs, such, for instance, as the liver.

We are all acquainted with the work of Dr. Weatherwax, and know how valuable are his calibrations, because they give us a rational basis and a quantitative measure on which to base treatment.

G. Failla (New York City): During the last four years a great deal of attention has been paid to the specification of dosage, particularly as regards the radiation which reaches the patient's skin. The latter problem seems now to be in a fair way to being solved for all practical purposes. On the other hand, the question of dosage as regards the tumor itself has hardly been touched.

Obviously the effect produced in a tumor depends in some way or other upon the amount of radiation which reaches it and the percentage absorbed there. In general, of course, it is impossible to put an ionization chamber at the most distant part of a tumor to measure the radiation at that point; accordingly we must rely on indirect determinations for the estimation of the radiation distribution within the irradiated tissue volume. The usual method is to use a water phantom and determine the distribution in the water: this gives a rough ap-

proximation of the actual distribution in the patient's body—there are many sources of error due to differences in size, constitution and density of tissues, air spaces, etc.

Dr. Weatherwax's experiments deal with the effect of differences in tissue density and air spaces. While with high voltage X-rays the difference in absorption between soft and hard tissues is not so great—as indicated by the fact that little contrast is shown in films taken with hard rays—there still is a difference. Air spaces, however, have a marked influence and data on this point are very valuable. Dr. Weatherwax is to be congratulated upon having undertaken this work.

J. L. WEATHERWAX (closing): The only thing I can say is that it seems almost impossible to make ionization chamber measurements inside of a living human being. If we try to make penetration measurements of radiation intensity in a cadaver, we have not reproduced the living. It would seem that, for a while at least, we must continue to use artificial means in making depth penetration measurements, and to apply these, if possible, to tissue.

# ROENTGEN THERAPY IN ACUTE INFLAMMATORY CONDITIONS[1]

By ERNST A. MAY, M.D., NEWARK, N. J.
Director of Metcalf Institute for Radiotherapy, Orange, New Jersey

FROM the advent of roentgenotherapy reports can be found on the beneficial action of the rays on acute inflammatory conditions. However, they are much more rare than reports on other diseases, as, for instance, malignant tumors. It is only now and then that one finds an author who deals with the successful treatment of acute inflammation.

Sokolow (1897), Stenbeck (1899), Albers-Schönberg (1900), and Moser (1903) reported on good results in acute arthritis. Stembo (1900) observed that a patient with extensive osteomyelitis became free of pain and that the local and general conditions greatly improved after a few X-ray exposures. Morton (1903) tried radiation in a case of extensive carbuncle of the neck. After the first exposure, lasting eight minutes, the condition changed very strikingly. The carbuncle became softer, pain gradually ceased, and the patient made a rapid recovery. Pfahler (1905) cured a case of pyogenic onychitis, which had failed to respond to other treatment over a period of twenty years. Coyle (1906) also reported that he obtained remarkable results in carbuncle. His work could be confirmed by Dunham and many others.

Evler (1907) first assembled a number of case reports on carbuncle and other circumscribed inflammations, which had been treated by X-ray with good results. From this time on reports have been more frequent. Cumberbatch reports on four cases of extensive osteomyelitis cured by short exposures. Bissel (1915) cured three cases of osteomyelitis in an early stage without the formation of sequestra. Further reports have been made by Slohan (1914), Kautz (1919), Freund (1921) and a number of others. There are also numerous reports on the beneficial action of X-rays in cases of lymphadenitis (Trostler, Evans, Leucutia and others), erysipelas (Magahas, Schrader, Platou, Rigler and others), nephritis (Stephan and others), inflammations of the adnexa (Wagner and others). However, if the entire literature is reviewed, there is as striking a lack of uniformity of reports as is found in the data on X-ray therapy of malignant tumors.

The reports are somewhat scattered and different authors follow their own intuition and experience. In 1923, Holfelder and I collected the entire literature of acute and chronic inflammations of bones and joints and compared it with our own experience. It appeared that almost every author used a different technic; that one saw results with high dosage and another with low dosage. We gained the impression that most of the results given in these previous reports had to be considered as more or less accidental and that they were not worked out on a scientific basis. For this reason the method failed when other roentgenologists wanted to use it in their own cases. Owing to the lack of uniformity in dosage as well as to the lack of exact measuring instruments and, not the least, of roentgenological experience, it was still more difficult to duplicate this method. It can be added that the danger of burning a patient and the fact that the old conservative and surgical methods were satisfactory enough, have kept the method from being used more generally.

Holfelder and I endeavored to put the

[1]Read by title at the Fourteenth Annual Meeting of the Radiological Society of North America, at Chicago, Dec. 3–7, 1928.

dosage for a single inflammatory disease on a standard, expressed in percentage of the biological erythema dose of Seitz and Wintz.

Unquestionably the credit of having created general interest in X-ray therapy of inflammations is to be given to Heidenhain and Fried (1925). They have proven the value of this method on more than fifteen hundred cases and have placed it on a scientific basis. Their results have been confirmed by many others, as Pordes, Wagner, Fraenkel, and Nissnjewitsch. These reports prove that no doubt another field has been opened to X-ray therapy.

### ACTION OF RAYS ON INFLAMMATION

(*A*) *On bacteria.*—Heidenhain calls attention to the fact that roentgenotherapy of acute inflammation has much in common with the treatment of tuberculosis. Tuberculosis in the end is nothing else than a chronic inflammation. In this disease the entire cycle of reaction to radiation takes months and years, while in acute inflammation it can be observed in hours and days. In both conditions the reaction is local as well as general. The improvement of the general condition frequently can be seen before a local change has taken place. The patient regains strength, his appetite improves, and he puts on weight. As Iselin expresses it, these are symptoms of clearing the body of toxins.

By animal experiments I have confirmed the findings of Motojima and others, that in radiated abscesses no living bacteria can be found. Many experiments have proven that the rays do not destroy the bacteria directly in such doses as are used in roentgenotherapy. There is a possibility that the rays may weaken the bacteria and indirectly produce from them an activation of bactericidal substances and proteolytic ferments and thereby increase local resistance. We also have to consider that changes of a physical and chemical nature which are common with every radiation add to the result, for instance, changes in the hydrogen-ion-concentration. The fact that numerous destroyed bacteria can be found in the pus of radiated furuncles proves that bacteriolysis and increased phagocytosis take place. Whether these ferments are derived from leukocytes destroyed by radiation or originate from increased function of the radiated area, is still uncertain. There may also be a similar reaction to that which one sees after injection of proteins.

Pordes sees a direct action of the X-rays in the destruction of leukocytes by the radiation of the inflammatory infiltrated tissue. Mechanically speaking, this leads to the relief of the intracellular pressure and to alleviation of pain. It also produces antibodies and other serological and immunizing effects. Fried has proven by experiments that the bactericidal properties of the circulating blood are also noticeably increased.

Bass and Jaroschka have found that by radiating an animal before and after inoculation, no immunization is produced, but, instead, a considerable increase of resistance against streptococci is obtained, to be found in every case. They say that this increase in resistance is produced by the activation of the entire reticulo-endothelial system radiating from the treated area.

In short, the mechanism of the action of the X-rays on inflammatory conditions is of a complex nature. Above all, it is a local one, assisted by a general effect due to the activation of the specific and non-specific forces of resistance.

(*B*) *On tissue.*—It is shown by experiments made by Arnold, David, and Gabriel, Fried, and Motojima that radiation acts on the tissue by producing an active hyperemia and serous infiltration of the tissue. One also finds an increased activity of repair, especially by development of connective tissue. The active hyperemia and the increased circulation of the lymph hinder or

dispose of the inflammatory infiltration in early cases, but after a necrosis of the tissue has taken place, the formation of an abscess cannot be prevented. By the influence of the increased forces of defense the process will soon be localized and its spread be prevented. This will result not only in shortening the duration, but an acceleration of the process in its different stages can be noted.

*In toto,* the reaction of the tissue to roentgen radiation has similar features in many aspects to the reaction to heat. Its effect will be increased if combined with the application of heat, as Motojima in his experiments and I in mine have observed in a number of cases.

## CLINICS

This can be seen especially well in cases of furuncle, carbuncle, acute lymphadenitis, or post-operative pneumonia. The temperature drops within twenty-four hours, the pain decreases rapidly, the appetite improves, and while the general bettering of the condition is slowly followed by an improvement in the local focus of infection, the symptoms of local and general reaction are so closely interwoven with each other that they cannot be entirely separated. In some cases the condition of the patient becomes slightly more severe but after this improves rapidly. If an abscess has not yet been formed, the temperature will drop in form of a crisis or lysis, the swelling will decrease, and the condition will improve without the formation of an abscess having taken place. In cases in which the inflammation is more advanced, the formation of a circumscribed abscess cannot be prevented, but it will heal up after a small paracentesis, leaving a very small scar. Still, in other cases in which a large amount of necrosis has already formed, the temperature may or may not drop, but there will be formation of an abscess which will also heal more rapidly after evacuation. The beneficial effect is noticed more readily when radiation takes place in the earlier stages, but good results can also be seen in cases in which the inflammation has spread. It is from this standpoint that one must judge the value of the method. Many authors have spoken of a positive result only when the formation of an abscess was prevented by radiation, but no doubt it is to the credit of X-ray treatment that the entire course of the disease is shortened and simplified.

Lymphangitis following paronychia will improve rapidly after radiation. The focus of infection will either be absorbed or a small abscess will form, which, after incision, will heal without delay.

The best results can be obtained with radiation therapy in furuncle, especially of the sweat glands. The treatment of this condition is not new, but the experience of the last few years has been profitable. Early cases will heal under treatment, without formation of abscess. In advanced cases one should not lose patience and an incision should not be made unless one is sure that an abscess has been formed. What has been said of cases of furuncle holds good in cases of other infections as parametritis, parotitis, orchitis, mastitis, pneumonia and others. In inflammation of the tendon sheaths, results can be expected if the case is radiated either before pus has formed or after the pus has been drained.

In osteomyelitis, surgical procedure has to antecede treatment. The advantage of radiation lies in the fact that these cases heal in a much shorter time when so treated. Sgalitzer has recently confirmed the observations made by Holfelder and myself, Heidenhain and Fried and others. Not only is the course of the disease shortened and with less interference, but recurrences also act favorably.

In acute arthritis, the result of the X-ray treatment appears shortly after radiation. A most striking result can be observed in cases

of gonorrheal arthritis. The condition of the patient is changed almost magically. The intense pain and swelling are relieved rapidly, and the joint can be moved more easily shortly after the treatment.

In all these cases in which the infection has been carried away from an original focus, it is necessary to give this focus special attention.

In erysipelas, we find that the rays are of beneficial action to both the local and systemic manifestations. They not only shorten the course of the disease, but also decrease the morbidity and mortality due to the disease (Platou and Rigler).

In lymphadenitis, the results are most gratifying. Heidenhain and Fried, Evans and Leucutia believe that radiation therapy will soon be one of the most important factors, second only to surgery, in the treatment of these conditions. In early cases a single dose is sufficient to make the glands disappear. If an abscess has formed, it should be drained by a small paracentesis. These cases will also rapidly recover.

Following the suggestions of Stephan, I have seen remarkable results in acute nephritis. Anuria may be relieved after a few hours by a flow of urine. I have the impression that the course of the disease is considerably alleviated and shortened.

Of twenty-four different diseases tried by Heidenhain and Fried, X-ray treatment was of distinct benefit to about 75 per cent. The best results have been seen in furuncle of the sweat glands, with 95.6 per cent. Good results to the extent of 80 to 85 per cent have been obtained in furuncle and other abscesses, lymphangitis, phlegmones, pneumonia, inflammation of the adnexa and inflammation around the teeth. Erysipelas, paronychia, lymphadenitis, and chronic suppuration after appendicitis belong to the next group, of which 70 to 73 per cent have responded. Parotitis, orchitis, and mastitis have resulted 60 per cent. Osteomyelitis, pleurisy, empyema, and sepsis have shown 45 to 50 per cent. Otitis media showed the poorest results (28 per cent). These results of Heidenhain and Fried have been confirmed by Pordes, Wagner, Holfelder, Fraenkel, and many others, all cases totalling several thousand.

The 235 cases I have treated is a rather small number in comparison with the 1,500 of Heidenhain and Fried. It is, therefore, impossible to express my results in each of the different types of inflammation in percentages. I have seen marked improvement in 81.3 per cent of my cases, while 18.7 per cent were doubtful or negative in reaction. I have omitted from these statistics all chronic cases—this as well as the advancement of the method in recent years may be the reason for my percentage being higher than that of Heidenhain and Fried.

TABLE I

| Disease condition treated | Marked improvement | Doubtful or negative reaction | Total |
|---|---|---|---|
| Furuncle of the sweat glands | 12 | — | 12 |
| Furuncle and carbuncle | 12 | 4 | 16 |
| Lymphadenitis | 64 | 9 | 73 |
| Sinusitis | 12 | 2 | 14 |
| Arthritis rheumatica | 17 | 4 | 21 |
| Arthritis gonorrhoica | 6 | — | 6 |
| Phlegmon | 2 | 1 | 3 |
| Pneumonia | 4 | 3 | 7 |
| Paronychia | 7 | 1 | 8 |
| Orchitis | 3 | 2 | 5 |
| Parotitis | 3 | 1 | 4 |
| Nephritis | 5 | 1 | 6 |
| Mastitis | 3 | 1 | 4 |
| Osteomyelitis | 9 | 3 | 12 |
| Tonsillitis | 14 | 2 | 16 |
| Erysipelas | 3 | 2 | 5 |
| Inflammation of adnexa | 9 | 4 | 13 |
| Otitis media | 3 | 2 | 5 |
| Pleural empyema | 3 | 2 | 5 |
| | 191 | 44 | 235 |
| | 81.3% | 18.7% | 100% |

DOSAGE

A number of early authors gave high doses, from 50 to 100 per cent of an erythema dose. Of the recent authors, Lawson uses low voltage of 70 to 100 K.V., with unfiltered rays, and gives a full erythema

dose. However, he speaks only of treatment of superficial lesions. Karp also gives high doses—up to three-quarters of an erythema unit. This, in my opinion, is the reason why he has not obtained satisfactory results. All the other authors who have recently entered this field are following the suggestions of Heidenhain and Fried and giving small doses. It is, therefore, advisable that these rules be adhered to strictly. Not enough warning can be given against too high a dose. According to Heidenhain and Fried, 10 per cent of a skin unit dose, which, after four weeks produces slight tanning of the skin in the adult, using 0.5 mm. of copper plus 3 mm. of aluminum filtration at 180 K.V., is supposed to be the lower line of useful dosage: 20 per cent may be considered as a medium dose: 25 per cent in many cases may be harmful. As a rule, only heavily filtered rays should be used and the skin should receive 130 to 260 r-units, which equals two to four Holzknecht units. It is not advisable to apply the rules of homogeneous radiation as we are accustomed to do in treating malignant tumors. Only the dose that strikes the skin is to be considered. The beam of rays should not only include the entire area of inflammation but also a large part of the surrounding tissue. Usually the treatment is to be repeated after from six to eight days, if considerable improvement has not taken place or the process has not gone back to normal. To radiate at shorter intervals is not advisable, the effect of radiation in the tissues being cumulative. However, I have found it quite useful to divide a single dose into two, of 10 to 15 per cent, with an interval of from one to three days, using the first dose somewhat as a trial dose. The earlier a case is subjected to radiation, the smaller is the dose to be given. In the case of children, the dose is also to be decreased.

The key to results is to give small doses at intervals arranged to meet the needs of the individual case. Each case should also be closely observed in consultation with the surgeon who has to decide on the proper moment of incision or whatever surgical procedure may prove necessary. Warning should be given against radiating deep-seated processes if surgical supervision and hospitalization of the case is impossible.

## CONCLUSION

Roentgen treatment of acute inflammatory conditions is of great help to surgery and also in more conservative methods. It cannot replace the old methods in the treatment of acute inflammatory conditions, but it is a very helpful adjunct to them. It not only alleviates pain but also affects the entire process of inflammation. It should not be undertaken, if proper surgical supervision is not available.

This beneficial action is produced by local and general effects. The local effects are hyperemia, dilatation of the blood vessels, increased circulation of the lymph and of other local immunizing processes. The general effect tends to increase the specific and non-specific forces of resistance. The entire procedure is not yet clearly understood.

The optimal dose of radiation lies between 130 and 300 r-units on the skin over the inflamed area, using heavy filtration and high voltage.

Two hundred thirty-five cases with acute inflammatory conditions were subjected to roentgen treatment by the author. In 81.3 per cent of these definite benefit from the treatment could be seen.

# EDITORIAL

M. J. Hubeny, M.D. . . . . *Editor*
Benjamin H. Orndoff, M.D.
John D. Camp, M.D. } *Associate Editors*

*Contents of RADIOLOGY copyrighted by the Radiological Society of North America.*

## CITATION FOR BRAVERY

Recently there came to the Editor's desk a letter so clear in its purpose of frankness and withal so unusual, that he is constrained to publish it, so that others may share with him in admiration of the writer's attitude. That part of the letter which is pertinent to the matter under consideration is as follows:

"I am writing to ask you to withhold the publication of the paper—read prematurely. I would be glad if it were not published until we have had some further time to observe the results.

"When I turned in this title, we had some fifty cases without evidence of recurrence for over two years, whereas in that group our normal number of recurrences would have been at least ten. Just prior to the meeting two cases of recurrence came in, and since the meeting I have seen two others.

"As the method is rather severe, I think it should not be published unless it is a distinct advance on other methods, and I feel that this is not sufficiently well established to justify publication. Had I had the information I now have, prior to the meeting, I should not have presented the subject at all."

The writer's attitude seems one of peculiarly well-considered withdrawal from publicity during a period of observation. He does not desire to be credited with having originated a new technic or method until he is sure of his end-results. Here is a commendable deliberation rather than the all-too-common "rushing into print." The writer runs the risk of sacrificing priority, in case his method shall prove a valuable one, preferring, rather, that he shall not have sponsored a form of therapy destined to inspire only false hopes.

In closing, it might be said that the writer of this letter is a man who has already attained outstanding success in the practice of radiology, who feels a sense of responsibility in advocating only those measures which have been proved by test.

A fearless man, not afraid to admit that he can still learn, wrote that letter.

---

## X-RAY STANDARDIZATION PROGRAM OF THE BUREAU OF STANDARDS

### I

The solution of the problems of X-ray standardization has arrived at a point where the Bureau of Standards is in a position to calibrate ionometers for the public.

The discrepancies between different standardizing laboratories in regard to the magnitude of the r-unit are now small enough to be neglected in connection with medical applications. The basis for this conclusion is the agreement within 2 per cent, recently obtained by a comparison, through the cooperation of Dr. Glasser, of two instruments from the Cleveland Clinic with those used by the Bureau; and the fair agreement

found earlier between the Cleveland Clinic instruments and those of the Reichsanstalt of Germany. Further comparisons will, of course, be made between the different national laboratories.

II

An ionometer sent to the Bureau may be calibrated for any condition of voltage and filtration desired, although all such instruments, to be accepted for calibration, must be adequately controlled by such means as radium or uranium oxide. This will minimize the possibility of undetected damage occurring to the ionometers in transit.

The following procedure is necessary to avoid delays and complication. Notify the Bureau as far as possible in advance of the shipment of the instrument, giving at the same time the type of instrument, date of purchase, method of controlling its calibration, type of X-ray machine with which it is used, peak voltage applied to the X-ray tube as actually measured with a sphere gap, and the half value layer in copper or the effective wave length of the radiation, with an explanation of how the measurement was made.

III

If the ionometer has been calibrated previously, a copy of the calibration should be supplied in order to complete the Bureau's records for every instrument it handles.

The cost of this service will depend upon the number of calibrations made for each instrument. A schedule of fees may be had upon request after sending in the information required above, in addition to stating the number of calibrations desired.

BUREAU OF STANDARDS
Department of Commerce,
Washington, D. C.

## TEN THOUSAND DOLLAR ANNUAL PRIZE AWARD FOR MOST VALUABLE ACHIEVEMENT IN SCIENCE

The largest single monetary award in America for scientific accomplishment has been created by *Popular Science Monthly*, which, beginning next Autumn, will confer an annual prize of $10,000, accompanied by a gold medal, upon the American citizen who has been responsible, during the preceding year, for the achievement in science of greatest potential value to the world.

In making this announcement, O. B. Capen, president of the Popular Science Publishing Co., explained that the award was instituted with a dual purpose—to heighten the interest of the American people in those conquests of the laboratory and the workshop which benefit the entire community, and to focus attention upon the many scientific workers who, without thought of personal profit, toil to better man's control over his physical surroundings.

The award will be bestowed under the auspices of the Popular Science Institute, a research organization maintained by the magazine, of which Prof. Collins P. Bliss, associate dean, New York University, is director. The Institute has enlisted the services of twenty-four leaders in American science to serve as a Committee of Award, whose task it will be to select the prize-winning effort.

The prize will be conferred for the first time in September, 1930, and the initial period of scientific accomplishment to be considered by the Committee of Award will be the twelve months ending June 30, 1930. All scientific workers, professional and amateur, academic and commercial, are eligible.

The distinguished men comprising the Committee of Award are: Dr. Charles G. Abbot, secretary, Smithsonian Institution;

Prof. Collins P. Bliss, director, Popular Science Institute; Dr. Samuel A. Brown, dean, New York University and Bellevue Hospital Medical College; Dr. George K. Burgess, director, United States Bureau of Standards; Dr. William W. Campbell, president, University of California; Dr. Harvey N. Davis, president, Stevens Institute of Technology; Dr. Arthur L. Day, director, Geophysical Laboratory, Carnegie Institution; Dr. E. E. Free, consulting engineer; Travis Hoke, editor, *Popular Science Monthly;* Dr. Frank B. Jewett, vice-president, American Telephone and Telegraph Co.; Dr. Vernon Kellogg, permanent secretary, National Research Council; Charles F. Kettering, president, General Motors Research Corporation; Dr. Arthur D. Little, president, Arthur D. Little, Inc.; Dr. John C. Merriam, president, Carnegie Institution; Dr. Robert A. Millikan, chairman, executive council, California Institute of Technology; Dr. Henry Fairfield Osborn, president, American Museum of Natural History; Dr. Elmer A. Sperry, chairman, board of directors, Sperry Gyroscope Co.; Dr. Samuel W. Stratton, president, Massachusetts Institute of Technology; Dr. Elihu Thomson, director, Thomson Laboratory of the General Electric Co., Lynn, Mass.; Dr. Edward R. Weidlein, director, Mellon Institute of Industrial Research; Henry Herman Westinghouse, chairman, board of directors, Westinghouse Airbrake Co.; Dr. Albert E. White, director, Department of Engineering Research, University of Michigan; Dr. Willis R. Whitney, director of research, General Electric Co., Schenectady, N. Y., and Orville Wright, co-inventor of the airplane.

"In the fifty-eight years of its existence," said Mr. Capen in his statement, *"Popular Science Monthly* has consistently striven to emphasize those advances which have proved of lasting value to the public. By so doing, it has encouraged scientific and inventive effort, helped to diminish drudgery, aided in increasing intellectual and material comforts, and assisted in providing the leisure to enjoy them.

"It seems particularly fitting, then, that *Popular Science Monthly* should take another step along the course it has pursued since its establishment in 1872. The creation of the award, it is confidently expected, will serve to further stimulate scientific and inventive activity in this country, especially along practical lines."

---

## WALTER TEED BRONSON

### 1887–1929

"His life was gentle,
And the elements so mixed in him
That all the world might rise up and say,
'This was a man.'"

At its best, life is uncertain—and death is certain. No truer words were ever spoken or written, and once again the verification of these truths was forcibly brought to our notice, when the grim specter of Death stalked into our midst and removed Walter Teed Bronson.

The large circle of friends who have felt the warmth of his nature will read these lines with grief, sorrow, and profound regret.

Walter Teed Bronson was born at Streator, Illinois, November 2, 1887. After attending the graded and high schools of his birthplace, he studied at Northwestern University, in Evanston, and in 1906 matriculated at the Medical School of that University, graduating as Doctor of Medicine in 1910. After a short period at Mercy Hospital, Chicago, as interne, he joined the staff of Minnequa Hospital, Pueblo, Colorado, as physician and surgeon for the Colorado Fuel & Iron Co., continuing in that capacity until July, 1918, when he answered his country's call.

July 14, 1918, he was commissioned First Lieutenant of the Medical Corps, U. S. A., and assigned to duty overseas with the 313th Infantry and the 304th Supply Train of the 79th Division. In April, 1919, he was commissioned Captain. During the Meuse-Argonne campaign he was very severely gassed, and was retired in May, 1919.

After his return home in 1919, he resided in Centerville, Iowa, doing a general practice, with a leaning toward surgery and radiology. Here he remained until 1922, when he moved to Chicago, becoming associated with the Englewood Hospital as roentgenologist, reorganizing the roentgenologic department and building it up to a high degree of efficiency in the seven years of his service.

In 1926 he was placed in charge of the Roentgen Laboratories of Northwestern University, on McKinlock Campus, Chicago, and at the same time began serving his alma mater on the faculty, as Instructor in Roentgenology.

He married Miss May Graham, September 2, 1913, while in practice in Pueblo, and to this union Walter Teed Bronson, Jr., was born, on September 28, 1915.

Capt. Walter T. Bronson, M.C.

Dr. Bronson was a Fellow of the American Medical Association and of the Chicago Roentgen Society; member of the Illinois State Medical Society, the Chicago Medical Society, the Radiological Society of North America, Delta Tau Delta, Beta Chapter, of Evanston, Phi Rho Sigma, Alpha Chapter, of Northwestern Medical School, Chicago Medical Post of the American Legion, Beachview Club, and the A. F. and A. M. At the time of his death he was representing his local branch of the Chicago Medical Society in the Council of that body, Secretary-Treasurer of the Chicago Roentgen Society, and Secretary-Treasurer of the Radiological Society of North America.

Possessed as he was of a kindly, helpful and genial disposition, he embarked wholeheartedly on the duties of the office of Secretary-Treasurer of the Radiological Society, and gave promise of a marked degree of efficiency and a long period of useful, helpful service. His life was clean, and he gave the best that was in him. He was a friendly man and he loved his friends and was beloved by them. His was a kind and genial nature, yet withal, he was a man of positive character and convictions and was firmly devoted to the cause of right, duty, and justice.

The funeral service in Chicago was attended by a large group of radiologists, other physicians, and mourning friends. His burial was at Streator, Illinois, the place of his birth, and was conducted by the Masonic Fraternity. He left a widow and fine young 14-year-old son to mourn his untimely demise.

In his passing, the Radiological Society lost an efficient officer, radiology lost an apt and able exponent, medicine lost a careful, studious, and competent physician, Northwestern University lost a capable instructor, the State lost a good citizen, and his bereaved family lost a good protector.

In closing, the writer is prompted to quote—

"And life is all the sweeter that he lived;
And all he loved, more sacred for his sake;
And earth is all the brighter, that he was here,
And Heaven all the happier, that he's there."

We shall miss you, Walter.

I. S. T.

---

## R. C. BAUMGARTEN: 1890–1930

The death of R. C. Baumgarten, M.D., of Seattle, Washington, occurred during the first week of February. He had been operated on for an acute appendix a week before, and the day before death had undergone another operation for paralytic ileus. Dr. Baumgarten was born in Davenport, Iowa, in 1890, graduated from the Jefferson Medical College, Philadelphia, practised medicine in Seattle since 1913, and became a member of the Radiological Society of North America in 1921. He was head of the X-ray department of the Children's Orthopedic Hospital and occupied a similar position with the United States Veterans' Bureau. He was a member of his county and state societies and of the American Medical Association.

Dr. Baumgarten's friends in the Society will be grieved to learn of his death, and will feel sympathy with the members of his family.

---

Penetrating radium rays have been used to test metal castings for flaws.—*Science Service.*

## DINNER IN DR. BUTLER'S HONOR

All past and present students and associates of Dr. P. F. Butler, of Boston, gathered at the Copley-Plaza Hotel in that city on the evening of January 25, at a dinner given in honor of their former "chief." The get-together followed immediately after the Radiological Conference of the Eastern Seaboard Cities, held at the Hotel Statler, in Boston, January 24 and 25. In addition to the guest of honor the following were present: Frederick W. O'Brien, M.D., Max Ritvo, M.D., Alexander S. MacMillan, M.D., Samuel Robins, M.D., Albert Maloney, M.D., George Rafferty, M.D., W. S. Altman, M.D., and Charles Galligan, all of Boston; Michael Cox, M.D., Pittsfield; Constantine Popoff, M.D., Haverhill; Sam Atkins, M.D., Waterbury, Conn.; N. G. Butler, M.D., Hartford, Conn.; Joseph Elward, M.D., Washington, D. C.; Anatole Desjardins, M.D., Wilkes-Barre, Penn., and J. E. Habbe, M.D., Milwaukee, Wisc.

The group informally organized themselves into the P. F. Butler Association and in the future, notes of Dr. Butler's weekly clinical-roentgenological conferences will be mailed to each member. Following the dinner and speechmaking, the guest of honor was presented with a gold watch and chain as a token of appreciation. It was planned to make the get-together dinner an annual affair.

---

## TEXAS RADIOLOGICAL SOCIETY

The Mid-winter Meeting of the Texas Radiological Society took place at Temple on the 27th and 28th of January. Clinics were held in the local hospitals, and, besides the program of scientific papers, the Canti Film was shown. The papers read were in part as follows:

"Mastoiditis without Clinical Symptoms

of Mastoid Disease," R. E. Barr, M.D., of Orange, Texas; "Pulmonary Tuberculosis," T. Bond, M.D., of Ft. Worth; "The Chronic Appendix," R. C. Curtis, M.D., of Corsicana, Texas; "The Line Focus Tube," Dalton Richardson, M.D., of Austin, Texas; "Tumors of the Mouth," Maxwell Murphy, M.D., and W. A. Chernosky, M.D., of Temple, Texas; "Technic for the Surgical Removal of Teeth" (with motion pictures), W. B. McCall, M.D., of Temple, Texas; "The Thymus Gland," J. B. Johnson, M.D., of Galveston; "Carcinoma of the Uterus," M. M. Roland, M.D., of Oklahoma City, Oklahoma; "The Optic Foramen," Davis Spangler, M.D., of Dallas; "Roentgen-ray Pelvimetry," C. L. Martin, M.D., of Dallas, and "Perforated Peptic Ulcer," G. V. Brindley, M.D., of Temple, Texas.

The officers of the Texas Radiological Society are: J. B. Johnson, M.D., of Galveston, *President;* W. G. McDeed, M.D., of Houston, *President-elect;* T. Bond, M.D., of Ft. Worth, *First Vice-president;* R. C. Curtis, M.D., of Corsicana, *Second Vice-president,* and C. P. Harris, M.D., of Houston, *Secretary-Treasurer.*

---

## COMMUNICATION[1]

86, Brook Street,
Grosvenor Square, W. 1, London.
4th December, 1929.

To the Editor, RADIOLOGY:
Dear Sir:

There is one practical difficulty which may militate against the general use of the valuable method of examining the esophagus, described by Dr. Hickey in the December number of RADIOLOGY, namely, the troublesome business of preparing the gelatine bougies. May I mention how this difficulty may be overcome?

I discarded the hard barium capsules as unsuitable for esophageal work many years ago and replaced them by the ordinary rectal glycerine suppositories made in various sizes, in which is incorporated as much barium sulphate as possible. These are made up by the dispenser. I have used them now for some twenty years and consider them indispensable for esophageal examination; in fact, the examination cannot be considered complete without having watched the larger sized pellet pass into the stomach. They are easily swallowed, melt slowly at body temperature, and keep indefinitely.

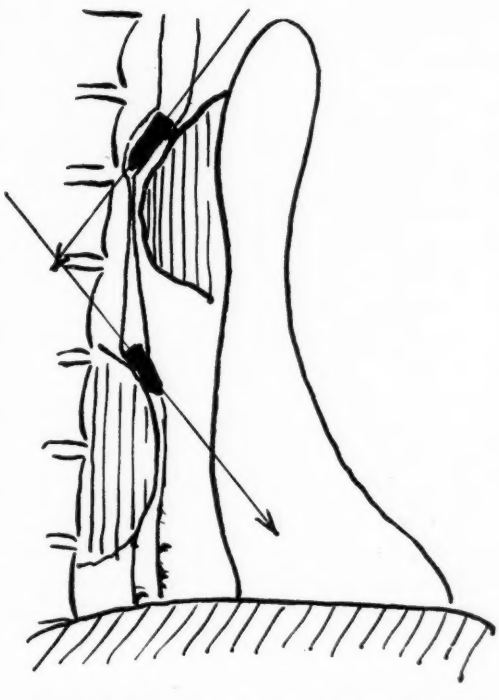


Diagram illustrating how the direction the pellet assumes in cases of stricture due to growth outside the wall of the esophagus indicates if the mass is exerting pressure from the front or the back.

Where the stricture is rather open a suitably sized pellet can be used to plug the

[1]Received through the courtesy of P. M. Hickey, M.D., University of Michigan.

opening. This, followed by a mouthful of the opaque emulsion, will often give most valuable information.

In cases where the stricture is due to growth outside the wall of the esophagus, the direction of the long axis of the pellet will indicate whether the mass is exerting pressure from the front or the back. If the long axis is directed towards the spine, the pressure of the growth is anterior; if away from the spine, the pressure is posterior.

S. GILBERT SCOTT, M.R.C.S.,
L.R.C.P., D.M.R.E. (Camb.)

---

## ESOPHAGEAL OBSTRUCTION: A PLEA FOR THE USE OF THE BREAD CRUMB METHOD

By A. E. BARCLAY, M.D., D.M.R.E. (Camb.),
CAMBRIDGE, ENGLAND

Dr. Hickey's ingenious plan for obtaining information as to obstructive lesions of the esophagus by means of gelatin bougies (RADIOLOGY, December, 1929) appears to have very considerable value, but, since these bougies must be freshly made, the method can come into general use only in large departments. The method will not find favor in private practice or in smaller departments unless Dr. Hickey can devise a preparation that will enable workers to keep these gelatin bougies in stock. Personally, I have always disliked and distrusted cachets and other opaque bodies of this class, and have trusted almost exclusively to a thick barium paste, if I failed with the thick emulsion.

As Dr. Hickey suggests, there is not the slightest doubt but that the early stages of obstruction are frequently missed—doubtless I have missed many myself, but on numerous occasions I have been saved by the use of a very simple accessory. Years ago, I had failed to find anything to suggest the presence of a lesion of the esophagus in a young girl on whose requisition card was written: "(?) esophageal obstruction, (?) hysteria." The case worried me, and on going carefully into the history I found that her symptoms were brought on only occasionally and by certain foods—bacon was one of them, as also was toasted bread. I, therefore, had some bread toasted hard and then crumbled. She ate a few spoonfuls of the crumbs without effect but presently said that a mouthful had brought on the pain. On giving her some opaque food we then found a typical obstruction at the level of the sixth dorsal vertebra. A diagnosis of ulcer was made on the hypothesis that it was a spasmodic obstruction due to the irritation of an ulcer crater by the crumbs, and that it was a simple peptic ulcer because of her age (18 years). The diagnosis was amply confirmed by the esophagoscope and subsequent history. Incidentally, the patient was eventually passed over to me for treatment. At that time I had treated a considerable number of rodent ulcers by ionization of zinc, with most successful results, on lines laid down by others. The manner in which this treatment was carried out in this case is noted in "The Alimentary Tract" (p. 30), published in 1914, and also in the Proceedings of the Royal Society of Medicine, Electro-therapeutic Section, Vol. VIII, 1915. I followed up the patient last year and found that there had been no recurrence and that she was the mother of several children. The diagnosis was therefore confirmed to the hilt.

I do not think that ordinary methods or Dr. Hickey's bougies would have made this diagnosis—the gelatin bougies would have slipped past the ulcer just as readily as my opaque paste had done. The fact is that in the esophagus there are often two factors in the obstruction, *i.e.*, spasmodic and organic. Cases of pure spasmodic obstruction are rarely met with—the patient complains of occasional obstructive symptoms and more often than not the ulcer is soothed rather

than irritated by the opaque substance, which protects the abraded surface. It is only when the ulcer is irritated into setting up a local spasm that we discover any obstruction to our opaque bolus, capsule, or whatever we employ. Organic obstruction, on the other hand, due to changes in the wall or from external pressure, is constant and should always be shown by the local delay and narrowing, if not by definite obstruction.

In cases of early carcinoma of the esophagus when, and if, the mucous membrane is just beginning to be involved, then the two elements are often combined. On many occasions I have been able to make certain of an ulcerative condition by applying the lesson I learned from the case to which I have referred. For the purpose I keep a tin of toasted bread crumbs always available. Whenever the clinical history of obstruction is at all intermittent or uncertain the examination *is started* by giving the patient a few spoonfuls of these crumbs in the hope that he will be able to swallow them, preferably unmasticated, or at any rate before they have become too soft to be effective. Of course, no liquid is allowed to wash them down even though the patient makes a fuss about it. In the end, he usually succeeds, but sometimes, possibly, after the crumbs have become too soft to be of any value for the purpose for which they are given. Perhaps some reader can suggest a less easily softened irritant. In these cases I have often intended to try the effect of liquid mild irritants, such as vinegar, for salad dressings have been noted several times as being responsible for accentuating obstructive symptoms.

In a few cases I have seen these hard toasted crumbs produce a definite hour-glass contraction of the stomach in an ulcerative lesion that, by ordinary methods, was not associated with any spasmodic hour-glass. All old workers recognize the fact that nowadays we note an hour-glass appearance of the stomach far less frequently than when we employed a bread-and-milk opaque meal, and it seems to me more than likely that the explanation lies in the smooth nature of the opaque meal that we now employ.

The bread crumb method is effective only in comparatively few cases, but it is so simple and so effective in these that I would urge workers to persist in its use. They will be rewarded by discovering a certain number of early ulcerative conditions, usually carcinomatous, which they would have missed by any method that did not primarily aim at irritating the ulcer and inducing spasm.

Dr. Hickey's method will certainly be of value in obtaining information about organic obstructions, but it must fail in those cases that depend to a greater or lesser extent on spasm, for the gelatin will be as soothing to an irritable surface as the jujubes that soothe our coughs and give us sweet repose.

---

## FIFTH INTERNATIONAL CONGRESS ON PHYSIOTHERAPY

The Fifth International Congress on Physiotherapy will take place in Liege, Belgium, September 14 to 18, 1930. Twenty-five foreign committees have been constituted, namely: France, Switzerland, Italy, Luxemburg, Holland, Denmark, Portugal, Spain, Germany, United States of America, Egypt, Japan, Sweden, Finland, Norway, Austria, Hungary, Argentina, England, Poland, Bulgaria, Brazil, the French Colonies, Canada, Peru. The chief questions to be treated will concern rheumatism and affections of the central nervous system, both belonging to the domain of physiotherapy. A third general question, concerning the university teaching of physiotherapy, will also be treated. A Belgian speaker and a German one are already appointed. Five speak-

ers are announced, from Holland, France, Denmark, Belgium, and the United States. In the divisions of kinesitherapy, physical education, radiology, electrology, hydrotherapy, thermotherapy, actinology, 22 reports and 49 communications are entered in the program. Up until the 6th of January, 350 had registered as planning to attend.

In order to make easy the organization of these important sessions, the Secretary-General, Dr. Dubois Trepagne, 25 Rue Louvrex, Liege, Belgium, desires all who wish to register to write him without delay. The Organizing Committee wish to receive papers before the 15th of April, in order that they may be able to print them. The subscription is 150 Belgian francs, payable to the Postcheque Account of the Congress, No. 243,065, Dr. de Keyser, Brussels, Belgium.

All requests for information should be addressed to the Secretary-General's office, 25 Rue Louvrex, Liege, Belgium.

## CORRECTION

Dr. H. J. Ullmann wishes to say that the following correction is to be read into his paper on "Fundamentals of Roentgen-ray Treatment," published in RADIOLOGY, January, 1930, XIV. In Table IV, on page 30, the heading over the last column should read "Percentage of surface dose at 4 cm. depth."

# BOOK REVIEWS

GALL BLADDER DISEASE: ROENTGEN INTERPRETATION AND DIAGNOSIS. By DAVID S. BEILIN, B.S., M.D., Roentgenologist, Augustana Hospital, Chicago, Illinois; formerly Instructor in Anatomy, University of Illinois College of Dentistry, Assistant Instructor in Surgical Pathology, University of Illinois College of Medicine. Published by Bruce Publishing Company, St. Paul, 1929. Pages 65. Price $6.00.

The author has endeavored to correlate the embryologic, anatomic, physiologic, and pathologic aspects of the gall bladder as it pertains to the cholecystographic interpretation and diagnosis of gall-bladder disease. The subject matter is brief but the essential facts have been presented. The clinical aspects of illustrated cases are presented, together with the roentgen diagnosis and physical and pathological findings.

The author prefers the oral method of cholecystography because it is the simplest and most efficacious method for routine work. The roentgen diagnosis was substantiated in an unusually high percentage of cases.

In the section "Roentgen Diagnosis of Gall-bladder Disease," the author's statement that "irregular, angular, and constriction deformities of the cap, without a niche, in a normal size stomach, without retention, associated with tenderness on palpation confined more to the gall bladder than cap, are very suggestive of duodenal deformity resultant from pericholecystic adhesions" will be objected to by many observers.

On the whole, this book should be a practical aid to those in need of a working basis for the roentgen diagnosis of gall-bladder disease.

ROENTGEN-RAY CHART (No. 3). PROF. E. BACHEM, 1337 Winona St., Chicago, Illinois, U. S. A. Chart is about 30 by 40 inches, printed on strong paper, metal-bound. Price, $5.00.

This is an attempt to illustrate graphically on a single wall chart the physical mensurations, the biological reactions, and the therapeutic indications of roentgen rays.

The chart gives a schematic diagram of a mechanically rectified apparatus, a comparison of dosage units, a spectrum, absorption curves, a formula for calculating dosage, a spark gap chart, biologic therapeutic indications, and treatment suggestions. Thus it contains in a condensed elementary form, some of the factors with which every therapist should be familiar. It might be of some use to beginners.

---

GRENZ RAY THERAPY. By GUSTAV BUCKY, M.D., New York, with contributions by DR. OTTO GLASSER, Cleveland, and DR. OLGA BECKER-MANHEIMER, Hamburg, Germany. Translated by WALTER JAMES HIGHMAN, M.D., New York. Published by the Macmillan Company, New York, 1929. Pages 170. Price $3.50.

In this book Dr. Bucky introduces an apparently original idea into radiotherapy. The so-called Grenz ray, in the author's opinion, deals with the somewhat nebulous zone of the spectrum between the ultra-violet and roentgen ray. He believes that the employment of this ray will produce unique clinical and biological manifestations. Whether this be true or not, the author's sincere and assiduous study of this seemingly new therapeutic modality is admirable. As usual under such circumstances, he is at times carried away by enthusiasm; nevertheless, the Grenz ray will bear most careful study in the future by those qualified. It has, as yet, no place in the hands of the general practitioner. The translation is good and the book can be recommended for the perusal of all interested in actinotherapy.

---

# ABSTRACTS OF CURRENT LITERATURE

INDEX TO ABSTRACTS IN THIS ISSUE


ABBOTT, M. E., and MOFFATT, W. Mirror-picture Dextrocardia, Complicated by Mitral Aplasia and Pulmonary Hypoplasia, with Great Hypertrophy of the Transposed "Right" Chambers ..... 436

BERTRAND, ALBERT, and MARIN, ALBERIC. A Study of the Effects of Long Wave X-rays on the *Staphylococcus aureus* and on the *Microsporum Audouini* ..... 427

BETHUNE, NORMAN. The Technic of Bronchography for the General Practitioner ..... 430

BÖDECKER, F. Contribution to the Measuring Methods in Skin Therapy ..... 441

BORAK, J. Roentgen Therapy in Climacteric Disturbances ..... 442

BRAILSFORD, JAMES F. Dislocations of the Lumbar Vertebræ ..... 429

BRAILSFORD, JAMES F. Pneumopyopericardium: the Radiological Diagnosis ..... 436

BRAUN, R., and KÜSTNER, H. The Physics of the Thimble Ionization Chamber: Second Communication ..... 441

BURNS, C. W. Diverticulum of the Esophagus: Report of Two Recent Cases ..... 431

CASATI, ANNIBALE. Experimental Investigations of the Roentgen-ray Effect on Bone Marrow ..... 440

CASE, JAMES T. The Present Status of the Roentgenological Diagnosis of Gallstones ..... 431

DANNMEYER, F. (*with* v. NOEL, L.) ..... 441

FALLIS, L. C. (*with* PRATTEN, F. H.) ..... 431

FENWICK, P. CLENNELL. The Radium Climacteric 427

FLINN, F. B., and SEIDLIN, S. M. Parathormone in the Treatment of Radium Poisoning: Preliminary Report ..... 427

FREUND, LEOPOLD. The X-ray Treatment of Wounds ..... 442

FRIED, HERMAN. Roentgenological Study of the Inverted Cecum ..... 435

FUHS, H., and KONRAD, JOSEF. The Results of Roentgen Therapy in Small Doses in Skin Diseases ..... 443

FUHS, HERBERT. The Treatment of Dermatological Conditions with Grenz Rays ..... 443

GÁL, FELIX. Treatment of Uterine Hemorrhage by Irradiation of the Spleen ..... 442

GARLAND, L. H. Gastric Motility ..... 432

GOLDEN, ROSS, and REEVES, ROBERT J. The Significance of Calcified Abdominal Lymph Nodes ..... 439

GORRELL, J. A. A Case of Volvulus of the Stomach, with Congenital Anomalies of Development ..... 433

GRAUER, SEPP. The Use of a Heavy Metal Filter in the Roentgen Treatment of Chronic Eczema ..... 443

HASE, ALBRECHT. Changes of Pigmentation in Insects Caused by Quartz Light ..... 444

HAUDEK, MARTIN. X-rays in Diagnosis of Early Carcinoma of the Stomach ..... 434

HILL, EBEN C. A Radiopaque Bismuth Suspension for Anatomical, Histological, and Pathological Research ..... 437

JOHNSTON, S. R. The Roentgenographic Study of the Gastric Mucous Membrane ..... 433

JONA, M. Comparison of Roentgen and Radium Doses with a Roentgen Dosimeter ..... 441

KARSHNER, ROLLA G. Pulmonary Tuberculosis of Infants and Children ..... 438

KEENAN, C. B., and WILKIE, A. L. Dislocation of the Semilunar Bone of the Wrist ..... 430

KOFOID, CHARLES A. (*with* NASSET, ELIZABETH CUSTER) ..... 428

KIRK, ELIZABETH (*with* PENDERGRASS, EUGENE P.) ..... 434

KONRAD, JOSEF (*with* FUHS, H.) ..... 443

KÜSTNER, H. (*with* BRAUN, R.) ..... 441

LINSER, KARL. Action of X-rays on Healthy and Diseased Skin ..... 443

LUDWIG, FRITZ, and v. RIES, JULIUS. Red as Antagonist of Ultra-violet ..... 444

MACKENZIE, A. J. Affections of the Esophagus .. 431

MCKIM, L. H. (*with* TEES, F. J.) ..... 429

MCMILLAN, J. CURRIE, and WHEELER, DIGBY. The Administration of Sodium Tetraiodophenolphthalein ..... 432

MARIN, ALBERIC (*with* BERTRAND, ALBERT) ..... 427

MOFFATT, W. (*with* ABBOTT, M. E.) ..... 436

MITCHELL, H. G. (*with* STRUTHERS, R. R.) ..... 439

MOORHEAD, E. S. Pyloric Spasm ..... 435

MORTON, RALPH. Rapidity of Healing of a Gastric Ulcer ..... 435

NASSET, ELIZABETH CUSTER, and KOFOID, CHARLES A. The Effects of Radium and of Radium in Combination with Metallic Sensitizers on *Endamœba dysenteriæ in vitro* ..... 428

v. NOEL, L., and DANNMEYER, F. On the Possibility of Obtaining Highly Active Ergosterin (Vitamin D) from Raw Coffee ..... 441

PATTERSON, W. J. Separation of the Lower Femoral Epiphysis ..... 429

PAULI, W. E., and SULGER, E. On the Bactericidal Effect of Roentgen Rays ..... 427

PAULI, W. E., and POLITZER, G. On the Effect of Cathode Rays upon the Resting Cells of *Salamandra maculosa* ..... 439

PENDERGRASS, EUGENE P., and KIRK, ELIZABETH. Significance of Gas under the Right Dome of the Diaphragm: with Discussion of Hepatoptosis ..... 434

PESQUERA, GILBERTO S. A Method for the Direct Visualization of Lesions in the Small Intestines ..... 435

PINNER, MAX. The Cavity in Pulmonary Tuberculosis: Roentgenologic and Anatomic Studies ..... 438

POHLE, ERNST A. Principles of Roentgenotherapy. I.—Fundamentals of Dosimetry ..... 441

POLITZER, G. (*with* PAULI, W. E.) ..... 439

PRATTEN, F. H., and FALLIS, L. C. A Case of Lung Abscess Treated by Artificial Pneumothorax ..... 431

RABINOWITCH, I. M. (*with* RITCHIE, W. L.) ..... 432

RAHWIN, MARCUS H. The Roentgen-ray Diagnosis of Acute Intestinal Obstruction ..... 435

RAISON, CAPT. T. W. Permissible Radiation Exposure in Radiography and Fluoroscopy ..... 440

REEVES, ROBERT J. (*with* GOLDEN, ROSS) ..... 439

REGAUD, C. Radium Therapy of Cancer at the Radium Institute of Paris: Technic, Biological Principles, and Results ..... 428

v. RIES, JULIUS (*with* LUDWIG, FRITZ) ..... 444

RITCHIE, W. L., and RABINOWITCH, I. M. On Laboratory Aids in the Diagnosis of the Gall Bladder and Its Passages ..... 432

ROWAN, ARTHUR A. Spontaneous Pneumothorax 430

SEIDLIN, S. M. (*with* FLINN, F. B.) ..... 427

SPARKS, J. V. The Difficulties of Comparative Radiography of the Chest ..... 430

STEEL, DAVID. The Roentgenological Findings in Mitral Stenosis and Insufficiency ..... 437

STRUTHERS, R. R., and MITCHELL, H. G. Congenital Tuberculosis: Report of a Case ..... 439

SULGER, E. (*with* PAULI, W. E.) ..... 427

TEES, F. J., and MCKIM, L. H. Anterior Dislocation of the Elbow ..... 429

THURSFIELD, HUGH. Thymic Asthma ..... 444

VOGT, E. On Roentgen Therapy of Inoperable Carcinoma of the Ovary ..... 442

WHEELER, DIGBY (*with* MCMILLAN, J. CURRIE) ..... 432

WHEELER, DIGBY. The Radiological Examination of the Heart and Great Vessels ..... 437

WILKIE, A. L. (*with* KEENAN, C. B.) ..... 430

## SUBJECT INDEX

Bactericidal Effect ..... 427
Radium ..... 427
Bone (Diagnosis) ..... 429
Chest ..... 430
Esophagus (Diagnosis) ..... 431
Gall Bladder (Normal and Pathologic) ..... 431
Gastro-Intestinal Tract (Diagnosis) ..... 432
Heart and Vascular System (Diagnosis) ..... 436
Tuberculosis (Diagnosis) ..... 438
Cathode Rays ..... 439
Dosage ..... 440
Experimental Studies ..... 440
Measurement of Radiation ..... 441
Roentgen Therapy ..... 442
Wounds (Therapy) ..... 442
Skin (Therapy) ..... 443
Thymus (Therapy) ..... 444

## BACTERICIDAL EFFECT

**A Study of the Effects of Long Wave X-rays on the *Staphylococcus aureus* and on the *Microsporum Audouini*. Albert Bertrand and Alberic Marin. Jour. Can. Med. Assn., May, 1929, XX, 496.**

The rays known as the long wave X-rays of Grenz, or borderline, or infra-roentgen rays, were tested out by the authors to determine the bactericidal action. The organisms cultured and exposed were *Staphylococcus aureus* and *Microsporum Audouini*. Whether pure cultures were exposed and then regrown, or injected into guinea pigs, no bactericidal action was noted.

L. J. Carter, M.D.

---

**On the Bactericidal Effect of Roentgen Rays. W. E. Pauli and E. Sulger. Strahlentherapie, 1929, XXXII, 761.**

In a previous article, the authors reported experiments in which they showed that the bactericidal effect of roentgen rays may be increased by 50 per cent if the temperature is raised from 18 to 37° C. during irradiation. The application of the dose in fractional form produces another increase of about 25 per cent. In this article, cultures of *Pyocyaneus* and *Staphylococcus* were exposed to roentgen rays of 125 K.V., 0.5 Zn., from 0.9 to 11.2 erythema dose (1 E.D. = 550 r). The bactericidal effect on *Pyocyaneus* was increased 80 per cent and on *Staphylococcus* 100 per cent if the temperature was raised from 37 to 41° Centigrade. A few animal experiments undertaken along the same lines must be supplemented before reaching final conclusions as to the identical effect *in vivo*.

E. A. Pohle, M.D., Ph.D.

---

## RADIUM

**The Radium Climacteric. P. Clennell Fenwick. Brit. Med. Jour., Sept. 7, 1929, No. 3,583, p. 455.**

In the menorrhagia of middle life radium has proved of so much value that if malignancy and fibroid disease are carefully excluded, radium can be safely recommended. The routine treatment has been one application of radium to the interior of the uterus lasting twenty-four hours; radium element, 50 mg. in platinum tube (wall thickness 1 mm.), enclosed in rubber tube (wall thickness 1 mm.); total dose 1,200 mg.-hours. As the uterine applicator is only the diameter of a No. 6 Hegar's dilator, an anesthetic is seldom required. In no case has any untoward symptom developed. In the majority of cases the bleeding has completely stopped in from four to six weeks from the date of treatment.

After very careful inquiry among women who are passing through the normal change of life no evidence could be found that the climacteric induced by radium treatment differs in any way, except in rapidity, from the normal period of disturbance experienced by middle-aged women. It is concluded that with increased experience in the use of radium many cases of intractable uterine hemorrhage will not be allowed to wait until chronic invalidism occurs, but will receive prompt relief from this new ally of our profession.

Wallace D. Mackenzie, M.D.

---

**Parathormone in the Treatment of Radium Poisoning: Preliminary Report. F. B. Flinn and S. M. Seidlin. Bull. Johns Hopkins Hosp., 1929, XLV, 269.**

The cases of radium poisoning referred to in this paper occurred among luminous dial painters and resulted from the habit of pointing the brush between the lips. Because of the ingestion and absorption of small amounts of this material and subsequent deposition of the radio-active material in the bones of the body, the organism is exposed to all three rays, alpha, beta, and gamma.

In the treatment of radium poisoning no specific indications have been reported up to the present time. The treatment so far has been purely symptomatic, directed along the lines of hygiene of the mouth, the prevention

and treatment of sepsis, the treatment of anemia, and general hygienic care.

MacCallum and Voegtlin found a lowering of the blood calcium in dogs after parathyroidectomy. Collip showed that the injection of his parathyroid extract raised the blood calcium and increased the calcium excretion. Aub and his co-workers found that the administration of parathormone in patients with lead poisoning caused considerable excretion of calcium from the bones along with the excretion of lead. The effect of parathormone on the calcium and lead excretion described by Aub has suggested the authors' method of treatment of the radium victims.

These patients were placed in a hospital and parathormone injections were given every other day, at first in very small doses of ten units which were gradually increased to forty. Electroscopic tests were made of the stools, by which it was definitely established that there is a slight normal elimination of radioactive material by way of the stools in these patients, but under treatment there is a definite increase in this elimination. At the end of a course of this treatment, the general condition of the patients showed marked improvement. They gained considerable weight, felt stronger, and were much improved in appearance.

The X-ray films of the bones in these cases were striking in that they showed lesions in the skull which seemed to be characteristic of this disease. These were sharply circumscribed, round areas of rarefaction in the skull, resembling those frequently seen in cases of myeloma or metastatic tumor. The skull removed during autopsy of a recent case of radium poisoning showed similar X-ray lesions.

HOWARD P. DOUB, M.D.

---

**Radium Therapy of Cancer at the Radium Institute of Paris: Technic, Biological Principles, and Results. C. Regaud. Am. Jour. Roentgenol. and Rad. Ther., January, 1929, XXI, 1.**

This paper presents the late results by radium therapy in the treatment of uterine cervical, cutaneous, and buccal carcinomas. Four methods of radium application have been employed in the statistics reported: (1) containers holding radium were placed in natural body cavities; (2) containers of radium were placed interstitially into the neoplasm by puncturing the skin or mucous membrane; (3) radium was applied to the surface of the body overlying the neoplasm; (4) large quantities of radium were placed at some distance from the skin overlying the tumor. For irradiating tumors from the shorter distances the author prefers molds made of a combination of beeswax, paraffin, and powdered wood. Such molds bearing radium containers on their outer surface, may be kept applied to the tumor area more or less continuously for as long as from eight to ten days. For the more deeply seated tumors, such as the pelvic carcinomas, quantities of radium up to 4 grams are suspended in a lead box swung on steel trunnions with a focal skin distance of 16 centimeters and a filtration equivalent of 1 millimeter of platinum.

The only cancers which have been regularly cured by radium therapy have been the epidermoid carcinomas. Adenocarcinomas are much more resistant and have not been cured except in a few instances. It is the author's belief that under present-day working conditions gamma rays of radium have an undoubted biologic superiority over roentgen rays in their greater selective action.

J. E. HABBE, M.D.

---

**The Effects of Radium and of Radium in Combination with Metallic Sensitizers on *Endamoeba dysenteriae in vitro*. Elizabeth Custer Nasset and Charles A. Kofoid. Univ. California Publ. (Zool.), 1928, XXXI, 387-416.**

The authors find that beta rays and to a lesser degree gamma rays of radium have a decidedly stimulating effect upon the division rate of *Endamœba dysenteriæ in vitro*, which is followed after twenty-four hours by a decided retardation. Both beta and gamma rays produce morphological changes in the amœba cultures; a large dose applied in a short time

has a more striking effect than smaller doses acting for a long time. Radium radiation killed the cultures when sub-lethal doses of mercury or lead chloride had been previously added. The remarkable resistance of the *Endamœba dysenteriæ* to radiation *in vitro* suggests that this agent would be valueless for treating human amœbiasis, unless the response to radiation *in vivo* is of a different order from that *in vitro*.

OTTO GLASSER, PH.D.

---

## BONE (DIAGNOSIS)

**Separation of the Lower Femoral Epiphysis. W. J. Patterson. Jour. Can. Med. Assn., September, 1929, XXI, 301.**

This is not so common an accident nowadays as it was in the days before the automobile displaced the horse and cart. It was called the "cart wheel fracture," owing to the fact that it so frequently resulted from catching the leg between the spokes of a wheel in attempting to climb on or off a wagon. The age occurrence is between eight and fourteen. The sex incidence shows that it occurs more frequently among boys, although modern tendencies will shortly equalize these figures.

The injury is a serious one, and there are many possible complications, such as injury to blood vessels and nerves and to growth. Reduction should be by manipulation, and not by the open methods. Two case reports are cited and illustrated by radiographs. Both resulted from automobile accidents, and both occurred in girls.

L. J. CARTER, M.D.

---

**Dislocations of the Lumbar Vertebræ. James F. Brailsford. Brit. Jour. Radiol., July, 1929, II, 344.**

Dislocations of lumbar vertebræ may be due to congenital malformation, chondro- or osteodystrophy, trauma, or disease. Malformations which may produce a dislocation are those of the neural arch or articular processes. However, it seems hardly reasonable to attribute spondylolisthesis to such an anomaly alone since many such anomalies are seen with no tendency toward dislocation, while, again, in some cases where spondylolisthesis can be demonstrated there is no evidence of congenital malformation. The author emphasizes the diagnostic value of the antero-posterior film in spondylolisthesis, such a view showing a characteristic outline of the anterior surface of the fifth lumbar vertebra.

A case of dislocation of the vertebræ at the dorsolumbar junction due to chondro-osterodystrophy is illustrated, the condition occurring in a child of four in whose case there was no history of trauma.

Traumatic dislocations are most commonly anterior dislocations of the upper segment on the lower segment, although lateral dislocations may occur. Spondylolisthesis due to trauma may result if the injury takes place in childhood, but in the author's experience has never occurred as a result of injury alone in adults.

The common disease process producing dislocation in the lumbar region is tuberculous caries of the spine, but if recognized and treated early, dislocations may be prevented.

J. E. HABBE, M.D.

---

**Anterior Dislocation of the Elbow. F. J. Tees and L. H. McKim. Can. Med. Assn. Jour., January, 1929, XX, 36.**

Anterior dislocation of the elbow is a comparatively rare lesion. Only twenty-three cases of complete anterior dislocation of both bones of the forearm at the elbow joint are recorded. Eight additional cases are on record in which the dislocation occurred through fracture of the olecranon.

Two cases are reported and illustrated. The first one is that of a boy aged six, with an anterior dislocation at the elbow joint, the tip of the unbroken olecranon resting on the lower extremity of the humerus. There was a fracture through the lateral epicondyle. The second case was that of a boy aged sixteen, with a fracture of the radius at the junction of the middle and lower thirds, and of the median epicondyle of the humerus. In addition, there

was a complete forward dislocation of both bones of the forearm at the elbow. Both cases ultimately had good functional results.

L. J. CARTER, M.D.

---

**Dislocation of the Semilunar Bone of the Wrist. C. B. Keenan and A. L. Wilkie. Jour. Can. Med. Assn., June, 1929, XX, 639.**

Two cases are reported, one treated by the open method of reduction, and the other by the closed method. Both patients were free from subsequent discomfort, and exhibited normal wrist movements in all directions.

The report is illustrated by radiographs made before and after treatment—in one case, eight months after, and in the other case, six weeks after. One case was complicated with fracture of the scaphoid: good union was secured.

L. J. CARTER, M.D.

---

## CHEST

**Spontaneous Pneumothorax. Arthur A. Rowan. Jour. Can. Med. Assn., July, 1929, XXI, 56.**

Artificial pneumothorax receives much mention in the literature, while accidental or spontaneous pneumothorax is spoken of but little. Spontaneous pneumothorax may occur (1) in the course of pulmonary tuberculosis, (2) as a complication of artificial pneumothorax, or (3) as a spontaneous collapse of the lung in which there is no evidence of tuberculosis. Typical cases illustrating each of these three varieties are cited. The symptomatology and treatment of each type are considered in detail.

L. J. CARTER, M.D.

---

**The Difficulties of Comparative Radiography of the Chest. J. V. Sparks. Brit. Jour. Radiol., July, 1929, II, 325.**

The writer emphasizes the necessity of an accurate timing device, accurate milliamperemeters and kilovoltmeters as well as standard dark room technic, in order to get comparable chest films at different times on a given individual. He illustrates the loss of definition and detail by over-exposing, over-penetrating, and improperly developing, and also considers variations in the milliamperage and distance factors. The exposure time should be kept at 4/20 second or less and the kilovoltage at not more than 75 K.V.P.

J. E. HABBE, M.D.

---

**The Technic of Bronchography for the General Practitioner. Norman Bethune. Can. Med. Assn. Jour., December, 1929, XXI, 662.**

The technic for the injection of iodized oil into the bronchial tubes makes it a simple office procedure within the reach of any general practitioner who owns or has access to an X-ray outfit. Being such a simple procedure it is in marked contrast to bronchoscopy, since the passing of a bronchoscope is the work of a specialist.

There are two methods of injecting the oil. The first is the well known Pritchard method, in which the oil is dropped in a gentle stream on the back of the forward-drawn tongue, and inhaled by the patient. The second method is a modification of the Pritchard method, the oil being injected through a curved cannula just over the top of the epiglottis into the middle of the vestibule of the larynx. The former method is for basal lesions, the latter for upper lobe ones.

The first preliminary step is to empty the bronchi. This is done by posturing the patient with the head down over the end of the table or bed for ten minutes. The injection is made on the X-ray table so that no time shall be lost or much movement be required between the injection and the fluoroscopy and radiography.

The best local anesthetic for basal lesions is 10 per cent cocaine solution swabbed on the base of the tongue, the soft palate, the uvula, the tonsils, the back of the pharynx, the epiglottis, and valleculæ. For upper lobe lesions the anesthetic must be applied, in addition, to

each piriform fossa, the back of the epiglottis, and the walls of the vestibule.

For basal lesions the patient is seated on a chair, the tongue drawn out, and 15 to 20 c.c. of the warmed oil dropped from a syringe through a straight cannula, the patient being gradually inclined toward the side to be filled. The patient is then fluoroscoped to determine the amount of filling, and a lateral flat film taken. The opposite lung is then filled, and antero-posterior stereoscopic films taken.

For upper lobe lesions the work must be done quickly. With the patient seated on the X-ray table, and everything ready to snap the radiograph, the curved cannula is placed, by the aid of a laryngeal mirror, with its tip in the vestibule of the larynx. The mirror is withdrawn, and 15 to 20 c.c. of iodized oil are quickly injected, the patient leaning well down and back on the selected side, and lying flat when the injection is finished. A few sharp short respirations will distribute the oil to the upper lobe. The film is then taken.

L. J. CARTER, M.D.

---

**A Case of Lung Abscess Treated by Artificial Pneumothorax. F. H. Pratten and L. C. Fallis. Can. Med. Assn. Jour., June, 1929, XX, 638.**

This case report is illustrated by radiographs before treatment, after the artificial pneumothorax, and four months later, when no opacity was visible. After the pneumothorax the temperature gradually returned to normal. The cough and sputum persisted for two months, then rapidly disappeared.

L. J. CARTER, M.D.

---

## ESOPHAGUS (DIAGNOSIS)

**Diverticulum of the Esophagus: A Report of Two Recent Cases. C. W. Burns. Jour. Can. Med. Assn., June, 1929, XX, 622.**

Diverticula of the esophagus are of two types, being classified according to the etiology of their production into traction diverticula and pulsion diverticula. The former are occasionally multiple. They occur at any point along the esophagus below the pharyngeal junction, and are thought to be due to traction on the esophageal wall from without, and involve all the muscular coats. Pulsion diverticula develop from pressure within the esophagus. They arise on the posterior surface of the esophagus at the point of junction with the pharynx, and involve only the mucous and submucous coats. The diagnosis is largely by X-ray examination, and the treatment is essentially surgical. Two case reports are detailed and illustrated.

L. J. CARTER, M.D.

---

**Affections of the Esophagus. A. J. MacKenzie. Jour. Can. Med. Assn., April, 1929, XX, 376.**

The affections dealt with are the commoner ones—spasm, simple stricture, diverticulum, and carcinoma. Cardiospasm will show a constriction at the lower end of the tube, with a smooth-walled dilatation above. In advanced cases it may be hard, even with the history and X-ray, to differentiate from carcinoma. Benign stricture, when due to corrosives, may simulate carcinoma, owing to its ragged appearance. But, when due to corrosives, the upper part will be most affected, and the stricture will be multiple. Diverticulum gives a characteristic X-ray appearance. A sac of rounded pouch-like shape, posterior, and always to the left of the esophagus, is seen. Carcinoma gives a characteristic X-ray picture of irregularly eroded wall, of a narrowed lumen with a dilatation above it, but when the growth is eccentric and situated in the wall there may be only a stricture seen. A complete picture may be secured by having the patient lie in the Sims position and suck up a thick mixture through a tube.

L. J. CARTER, M.D.

---

## GALL BLADDER (NORMAL AND PATHOLOGIC)

**The Present Status of the Roentgenological Diagnosis of Gallstones. James T. Case. Jour. Can. Med. Assn., April, 1929, XX, 380.**

We may expect, with ordinary routine tech-

nic, to demonstrate positive shadows of the calculi by direct X-ray examination in at least 30 to 40 per cent of the cases of gallstones. With the advent of the Graham method of cholecystography the percentage of correct X-ray diagnoses of gallstones has advanced to 95 per cent. These figures are based on the writer's series of 277 consecutive cases submitted to operation.

Dr. Case uses exclusively the intravenous method of administering the dye. In reporting on the cholecystographic examination he uses the following terminology:

(1) *Stone positive.*—Gallstones show as negative shadows.

(2) *Absence of shadow.*—Failure to discover a gall-bladder shadow, especially when the dye has been given intravenously, constitutes the most convincing, reliable, and important evidence of disease of the biliary tract.

(3) *Pathological, non-calculous.* — These terms are applied to gall-bladder shadows that do not show stones, but are lacking in density, or slow in emptying, or irregular in outline.

(4) *Normal.*—Means normal outline at the fourteenth hour, uniform normal density, and normal emptying.

L. J. CARTER, M.D.

---

**The Administration of Sodium Tetraiodophenolphthalein. J. Currie McMillan and Digby Wheeler. Jour. Can. Med. Assn., April, 1929, XX, 390.**

The authors used the intravenous method on fifty cases, then discarded it because of the frequency of severe systemic reactions, the risk attendant on any intravenous procedure, and the amount of time required.

The oral method, using capsules, was tried, but was not satisfactory. Under this method pathology in the biliary tract, as indicated by absence of the gall-bladder shadow, totalled 61 per cent, a percentage far too high.

Since February, 1928, they have used the "grape juice method" as a routine. This method is simple, has few reactions, and is accurate. Under it, 38 per cent of cases referred for functional gall-bladder test showed biliary tract disease.

The technic consists in dissolving 45 grams of "Iodeikon" in 1 oz. of water, filtering this into an 8-oz. bottle, and filling it up with undiluted grape juice. This is given at 8:30 P. M., three hours after a light meal with fat content higher than usual. Plates are made at twelve and sixteen hours; then a lunch with high fat content is given, and another plate taken at 4:30 P. M.

L. J. CARTER, M.D.

---

**On Laboratory Aids in the Diagnosis of Disease of the Gall Bladder and Its Passages. W. L. Ritchie and I. M. Rabinowitch. Jour. Can. Med. Assn., March, 1929, XX, 263.**

There is a close relation between cholecystitis, pancreatitis, and diabetes. In 10,000 admissions to the Montreal General Hospital the incidence of diabetes was 2 per cent, whereas in 300 cases with a diagnosis of cholecystitis, cholelithiasis, or pancreatitis, the incidence of diabetes was 7 per cent. This would suggest the necessity of all cases of diabetes having a routine X-ray gall-bladder examination. Further, the close association of cholecystitis and pancreatitis makes it advisable that all gall-bladder functional examinations (dye tests) should be supplemented by a blood sugar time curve test, to show the efficiency of the pancreas.

Forty-three cases were analyzed from the standpoint of these two tests. Of these, twenty-eight cases showed blood sugar time curve and X-ray both positive, and all were found at operation, or by the pathologist, to have gall-bladder disease. Nine cases showed positive blood sugar time curve and negative X-ray, and the operative or pathological report was cholelithiasis. The X-ray findings showed 75 per cent correct, while the chemical test was 88 per cent correct. Both laboratory tests should be used.

L. J. CARTER, M.D.

---

## GASTRO-INTESTINAL TRACT (DIAGNOSIS)

**Gastric Motility. L. H. Garland. Brit. Jour. Radiol., May, 1929, II, 233.**

The writer takes up both the older and newer theories as to the origin of gastric muscular

activities (included in which term are both the static or tone and kinetic or peristaltic factors), and accepts the theory of the origin of peristaltic waves in a nodal center below the cardiac orifice, the contraction passing downward as a conduction wave along the lesser curvature and stimulating each circular group of muscle fibers to a transient increasingly deep contraction, such contractions being coordinated and synchronized by means of Auerbach's plexus. The two factors controlling the opening of the pyloric sphincter are the efficiency of the peristaltic wave and the fluidity of the gastric content. Normally pyloric tone keeps the sphincter in a state of equilibrium, its opening being affected by a rise in pressure on either side, hence, an increase in pressure in the duodenal bulb immediately following a retrograde duodenal wave, will cause a reflux of duodenal contents into the stomach.

After giving consideration to pathological gastric motility the author agrees with Alvarez, Boyd, and others that alterations of gastric or intestinal motility are of greater significance in the causation of disease than secretory disorders.

J. E. Habbe, M.D.

---

**A Case of Volvulus of the Stomach, with Congenital Anomalies of Development. J. A. Gorrell. Jour. Can. Med. Assn., October, 1929, XXI, 427.**

A male child ten months of age was taken severely ill with pain and vomiting. A mass was found in the upper abdomen. At operation a dilated stomach was found, rotated from right to left on a vertical axis passing through the cardiac orifice. The duodenum was wound one complete turn around the pyloric orifice, causing complete pyloric obstruction. On rotation of the stomach from left to right both orifices became normal. The patient continued to vomit and lived fourteen hours after operation. Autopsy showed a great omentum one inch long, which did not contain the transverse colon, that being attached to the posterior abdominal wall by a mesentery of its own. The gastrohepatic omentum was five inches long, and allowed of the stomach being very mobile. The spleen was attached to the posterior part of the cardiac end of the stomach, and was supplied by the right and left gastroepiploic arteries.

L. J. Carter, M.D.

---

**The Roentgenographic Study of the Gastric Mucous Membrane. S. R. Johnston. Can. Med. Assn. Jour., December, 1929, XXI, 683.**

The author makes a brief résumé of the work done by Forssell and other pioneers in the study of the physiology of the gastric mucous membrane by means of the X-ray. The technic used by the author is indicated. The most satisfactory opaque mixture consists of three parts of mucilage to two parts of barium. One to two teaspoonfuls of this mixture is given, with the patient in the recumbent position. The head of the table is then raised through about a 15-degree angle, sufficient to cause the barium to reach the pylorus in a reasonable time. Palpation should be avoided.

Two methods of study are available: First, the taking of films after the barium has spread itself on the surface of the stomach, and, second, fluoroscopic observation. The phenomena noted are changes in the conformation of the folds of the mucosa, retrograde movements of the barium without changes in the configuration of the longitudinal folds, and pooling of the barium into small masses. The author believes that the erosions of the mucosa in the condition known as achlorhydria gastrica hemorrhagica can be detected by this method of examination. In chronic interstitial or hypertrophic gastritis the rugæ are enlarged and irregular and no movements are seen. In atrophic gastritis the rugæ are seen as finely pencilled lines with few or no cross-divisions, and a complete absence of movements.

The author believes that this method of examination will be helpful in the investigation of other problems, such as: (1) ulceration on

the posterior surface; (2) a more detailed study of cancer; (3) differentiation of extragastric pressure from intrinsic defects; (4) differentiation of spasm from organic lesions.

L. J. CARTER, M.D.

---

**Significance of Gas under the Right Dome of the Diaphragm: With Discussion of Hepatoptosis. Eugene P. Pendergrass and Elizabeth Kirk. Am. Jour. Roentgenol. and Rad. Ther., September, 1929, XXII, 238.**

Gas under the right dome of the diaphragm may be produced by ruptured viscus, subphrenic abscess, hepatoptosis (gas in colon), dextrocardia (gas in stomach), and following abdominal operation for a period of 24 or more hours. The lateral erect view is considered more reliable for small amounts of air than the antero-posterior erect one. Two cases of hepatoptosis are reported, and the differential X-ray diagnosis between this condition and ruptured viscus is discussed.

J. E. HABBE, M.D.

---

**X-rays in Diagnosis of Early Carcinoma of the Stomach. Martin Haudek. Brit. Jour. Radiol., September, 1929, II, 421.**

According to Haudek, 40 per cent of all cancer deaths are due to gastric cancers, the majority of which are not resectable at the time of diagnosis or exploration. Since surgical removal is the only method of treatment offering any hope of cure, it is obvious that some further efforts must be made to arrive at reliable diagnoses at an earlier stage in the course of the disease.

At the Eiselberg Surgical Clinic, in Vienna, in 1908, prior to the institution of X-ray examinations the percentage of resectable stomach cancers was 22, while in 1924 the percentage had risen to 40 (of those subjected to operation). Four reasons for later X-ray diagnoses are: the latent period, delayed X-ray investigation, faulty X-ray study, and incompleteness of present X-ray technic. Great emphasis is placed upon the necessity of radiographic study in addition to fluoroscopy if one hopes to detect the earlier mucous membrane changes in small carcinomata. Three films in the standing, prone, and supine positions, with only 30 c.c. of thick barium emulsion in the stomach, are made to show normal or abnormal "relief pattern," and two with the stomach filled, one standing and one prone.

In adenocarcinoma, usually located at the lesser curvature, a crater is often seen, which is frequently mistaken for a niche. However, in carcinoma the rugæ terminate outside the tumor, there is a translucent zone representing the wall of tumor surrounding the crater, and the tumor recedes in steps along the lesser curvature.

Medullary carcinomata, when small, show a small central filling defect like benign tumors, but if malignant the tumor edges are apt to be less sharply defined. Since a large percentage of all adenomata undergo malignant degeneration, and since some authorities believe the majority of gastric carcinomata arise in adenomata and polypi, it is obvious that treatment in all such cases is entirely surgical.

The pathognomonic sign of scirrhus carcinoma is the "spigot" form at the pyloric end of the barium shadow. The spigot lies along the lesser curvature, with the greater curvature being drawn inward, in contradistinction to pre-pyloric ulcer, where the indrawing is of the lesser curvature.

Carcinoma fibrosum permits of no early diagnosis in the sense of showing a resectable tumor, but does show the filling defect high in the media when palpation of the abnormally small, highly situated stomach is still impossible.

In discussing differential diagnosis of ulcer and cancer in the pre-pyloric portion of the stomach, Haudek gives as reasons the infrequency of a niche in ulcers in this region and the tendency toward a marked submucous edema and associated gastrospasm in ulcers in this part of the stomach. However, since about one-third of such ulcers undergo malignant degeneration the necessity of early surgical removal is reiterated.

J. E. HABBE, M.D.

**Pyloric Spasm. E. S. Moorhead. Jour. Can. Med. Assn., January, 1929, XX, 17.**

The writer describes the etiology and symptomatology of pyloric spasm, which is the frequent cause of upper abdominal pain. Symptoms similar to those produced by pyloric spasm may be reflexes from such conditions as cholecystitis, duodenal ulcer, or chronic appendicitis, but true pyloric spasm is purely a functional condition. If the condition is purely functional, that is, a simple pyloric spasm, relief will be obtained by giving six minims of tincture of belladonna with a few grains of sodium bicarbonate, before each meal. The statement is made that if the pain and other symptoms from which the patient suffers are due to ulcer, to cholecystitis, or to a chronic appendicitis, there will be no relief from such a simple line of treatment.

Three case reports are cited, in which the roentgenologist's findings were gastric or duodenal ulcer, which findings were, however, questioned by the author, since the pain complained of was promptly relieved by belladonna and soda, a conclusion, the Abstractor believes, which most gastro-enterologists will find it difficult to accept.

L. J. Carter, M.D.

---

**The Roentgen-ray Diagnosis of Acute Intestinal Obstruction. Marcus H. Rahwin. Am. Jour. Surg., November, 1929, VII, 656.**

Acute intestinal obstruction shows a mortality of between 40 and 50 per cent. The author believes that if the diagnosis could be made in the first few hours of the condition rather than within the first few days, the mortality could be made comparable to that of acute appendicitis. The use of the roentgen ray is one of the most promising diagnostic procedures which makes earlier diagnosis possible. The technic is very simple and consists of an ordinary flat film of the abdomen. The diagnosis of obstruction is based on the character and distribution of gas shadows in the bowel. The interpretation of the films, however, demands correlation with the clinical facts. The author points out that he has been unable to differentiate from the films in all cases a mechanical ileus from the so-called paralytic ileus. This method was first suggested by Case in 1914. No new findings are discussed in this article.

Howard P. Doub, M.D.

---

**Rapidity of Healing of a Gastric Ulcer. Ralph Morton. Brit. Med. Jour., June 8, 1929, No. 3,570, p. 1037.**

Dr. Morton agrees with Barclay that it is impossible to tell from a radiograph whether an ulcer is of a penetrating variety or not; much of the appearance of penetration is due to heaping of the gastric mucosa, combined with surrounding inflammatory exudate. The extent of the disease can be judged in such cases only by correlating the radiographic appearances with the actual clinical symptoms and signs.

Wallace D. Mackenzie, M.D.

---

**A Method for the Direct Visualization of Lesions in the Small Intestines. Gilberto S. Pesquera. Am. Jour. Roentgenol. and Rad. Ther., September, 1929, XXII, 254.**

As an aid to the usual gastro-intestinal X-ray study the author passes a duodenal tube, and through this a barium-acacia-water mixture is directly introduced for study of the duodenum, jejunum, and ileum. A case is reported of obstruction in the lower ileum which probably arose as a lipoma of the mesentery, with secondary inflammation and polyposis of the affected area of the bowel.

J. E. Habbe, M.D.

---

**Roentgenological Study of the Inverted Cecum. Herman Fried. Am. Jour. Roentgenol. and Rad. Ther., December, 1928, XX, 531.**

The author believes that the inverted cecum constitutes a distinct clinical and roentgenological picture. The individual with such an anomaly may complain of attacks of abdominal pain coming on six to ten hours after a

heavy meal and usually relieved by a change of posture. Two of the three cases when studied roentgenologically could be shown to have inverted ceca, which, by changing the patient from the horizontal to the vertical, or *vice versa*, could be made to descend and assume a normal relationship to the ascending colon. In the third case the inverted cecum was shown to be adherent in that relation to the ascending colon.

J. E. HABBE, M.D.

---

## HEART AND VASCULAR SYSTEM (DIAGNOSIS)

**Pneumopyopericardium: the Radiological Diagnosis. James F. Brailsford. Brit. Med. Jour., Dec. 7, 1929, No. 3,596, p. 1053.**

The conditions of pneumohydropericardium and pneumopyopericardium are rarely diagnosed. They may exist, yet their presence may be unsuspected owing to their insidious development during the progress of a grave lesion, or to the physical signs and symptoms of the primary lesion masking those of these conditions.

Pneumopyopericardium may arise from any lesion which leads to perforation of the pericardium from within or without, such as (1) rupture of the pericardium by a foreign body in the esophagus or stomach by a puncture wound; (2) paracentesis; (3) direct violence, with or without a definite fracture of a rib or the sternum; (4) artificial pneumothorax; (5) the breaking down of a tuberculous lesion in close proximity to the pericardium; (6) the rupture of inflammatory lesions near the pericardium—abscess (lung, liver, subdiaphragmatic), empyema, etc.; (7) carcinomatous ulceration of esophagus, bronchi, or stomach.

The diagnosis of pneumopericardium can be definitely established only by an X-ray examination. Normally the pericardium invests the heart so closely that it cannot be seen on the radiograph (except perhaps at the left cardiophrenic angle), even though pericarditis exists, unless this has been present over a long period of time and calcification of the pericardium has occurred. It is only in a few selected cases of pericarditis with effusion that we get a double contour of the heart shadow, and on the other hand definite cases of pericarditis with effusion exist in which no such radiographic shadows can be found. Moreover, such appearances may be shown on antero-posterior radiographs where no pericarditis is present; such lesions as a pleuritis, mediastinalis, dilated esophagus, paravertebral abscess, or aneurysm of the abdominal aorta, may give such a picture. It is essential in the radiography of the heart that the best technic be adopted, and the chief factor is undoubtedly shortness of exposure.

The form which the pericardium usually assumes when dilated by a large collection of gas and fluid, is as follows: The widest part of the pericardial sac is at the level of the fluid surface, the base of the pericardium being narrower. The general shape of the pericardial sac is ovoid, except for the notch due to its attachment to the aorta and pulmonary artery. The pericardium is more dilated to the left than to the right. In the differential diagnosis further conditions which may give similar appearances and therefore must be kept in mind are empyema localized in the mediastinal area; echinococcus cysts which have ruptured and partly drained, and mediastinal tumors, the middle of which have disintegrated, liquefied, and partly drained.

In making a diagnosis it is of the first importance to take radiographs in several planes, and to rotate the patient during screening, as it is impossible from an antero-posterior radiograph to state definitely that the fluid and gas are in the pericardium.

WALLACE D. MACKENZIE, M.D.

---

**Mirror-picture Dextrocardia, Complicated by Mitral Aplasia and Pulmonary Hypoplasia, with Great Hypertrophy of the Transposed "Right" Chambers. M. E. Abbott and W. Moffatt. Jour. Can. Med. Assn., June, 1929, XX, 611.**

This is a condition in which the heart is malposed to the right in the thorax, as a result of a congenital malformation of the organ it-

self. Two types occur: In the true mirror-picture dextrocardia, the heart is in the condition of situs inversus, its chambers and orifices bearing a reversed relationship to each other, the apex pointing to the right axilla, and formed of the left ventricle; in the other type the heart is not transposed upon itself, but lies to the right of the median line, the right border projecting below the left, and giving the effect of an apex on the right side. The two types may be differentiated by the electrocardiogram, which is characteristic in the true mirror-picture dextrocardia.

A most interesting case report is given and the X-ray and postmortem findings fully discussed. The case was of the true dextrocardia type, but certain anomalies were associated. There was true situs inversus of all chambers of the heart and of the great trunks, but the aortic arch and the lungs remained untransposed. The left ventricle had undergone aplasia, and most of the systemic circulation was carried on by the hypertrophied right ventricle.

L. J. CARTER, M.D.

---

**The Radiological Examination of the Heart and Great Vessels. Digby Wheeler. Jour. Can. Med. Assn., August, 1929, XXI, 189.**

The rôle of the X-ray in the examination of the heart is summed up as follows: The X-ray offers confirmatory evidence in the study of the alteration of one or more chambers of the heart, the position of the heart within the chest, the movements of the heart, fluid or gas in the pericardial sac, and calcification, aneurysm, or dilatation of the thoracic aorta.

X-ray examination is the only procedure which can accurately demonstrate the form and size of the heart, the enlargement and pulsation of each chamber separately, calcifications of the pericardium or thoracic aorta, small aneurysms, and dilatations of the thoracic aorta. Photographs are shown of the normal heart hardened *in situ*, removed from the thorax and placed in the anatomical position, four different angles being used in the exposure. Heart chambers were filled separately with an opaque solution, and radiographs taken to show what each chamber contributes to the cardiac shadow. Reproductions of these radiographs are shown.

L. J. CARTER, M.D.

---

**A Radiopaque Bismuth Suspension for Anatomical, Histological, and Pathological Research. Eben C. Hill. Johns Hopkins Hosp. Bull., April, 1929, XLIV, 248.**

The author goes into the literature on this subject, naming the various opaque materials which have been used in the past for injecting the blood vessels, and describing experiments which he has carried out in an endeavor to find a suspension which would delineate the very finest capillaries in the body.

He has found that a finely divided bismuth oxychloride suspended in a solution of gum acacia is most satisfactory for postmortem radiographic study of the vascular system. For most purposes a suspension of 20 per cent bismuth oxychloride in an 11 per cent solution of acacia gives excellent delineation, but this percentage can be changed to suit the varying conditions. The acacia serves as an agent to aggregate the finely divided particles of bismuth, and by employing cloth filters of various meshes, unit masses of any desired size may be obtained. Tissue injected with this radiopaque suspension may be studied microscopically either as cleared specimens or in stained histological sections. In both, the bismuth is clearly delineated from the surrounding tissue.

Details of the method of preparing this suspension and of the technic used in injecting the various parts of the body can be obtained from this article.

HOWARD P. DOUB, M.D.

---

**The Roentgenological Findings in Mitral Stenosis and Insufficiency. David Steel. Am. Jour. Roentgenol. and Rad. Ther., March, 1929, XXI, 220.**

As studied fluoroscopically and by seven-foot films taken in the anteroposterior and

both oblique positions, and checked by postmortem examination, the following roentgenologic evidences may be seen in a case of mitral stenosis: heart is in erect position and appears long and narrow, left border straight, left median distance small, aortic knob hidden behind spine, pulmonary arch higher up, pulmonary artery increasingly prominent, right auricle curve long and joining ascending aorta higher, hilus regions increased and right pulmonary artery (when visible) widened. The film made with the patient in the first oblique position shows the enlarged left atrium encroaching upon or obliterating the mid-portion of the retrocardiac space with, however, the lower third of the retrocardiac space normally clear. The esophagus, when filled with barium, will be displaced to the right by the enlarged left atrium. The author emphasizes the fact that even with marked enlargement of the left auricle it does not of itself form any portion of the left side of the cardiac silhouette, but, rather, encroaches upon the posterior space or may even project to the right, beyond the right auricle shadow.

In mitral insufficiency the left ventricle enlarges, which increases the left median distance. Whereas in stenosis the cardiac incisura is filled out, in mild cases of insufficiency the dilated left ventricle may cause the incisura to be restored; however, in advanced cases the incisura becomes lost because of the dilatation of the pulmonary artery.

A pure right-sided hypertrophy may be differentiated from a case of mitral stenosis by showing a rotation only, without actual left auricular enlargement.

J. E. Habbe, M.D.

---

## TUBERCULOSIS (DIAGNOSIS)

**The Cavity in Pulmonary Tuberculosis: Roentgenologic and Anatomic Studies. Max Pinner. Am. Jour. Roentgenol. and Rad. Ther., December, 1928, XX, 518.**

Three roentgenological types of cavities are described and illustrated by case reports. The first type is that showing multiple small "moth-eaten" areas in infiltrated parenchyma. This type, studied by postmortem material, shows no defense on the part of the surrounding lung structure. The second type, the "round" cavity, shows beginning defense by the host against an acute lesion, with the prognosis being somewhat more favorable where the cavity outline is thin and sharply defined than where a broad exudative border is seen on the film. The third type of cavity is the fibrotic, thick-walled cavity, which frequently shows an irregular outline. Such a cavity may be quite typical pathologically but is not always clearly demonstrable roentgenologically because of the fibrosis and marked pleural thickening. This type usually represents a chronic stage of cavitation, although such a cavity may be the cause of sudden bronchogenic "spreads."

From the therapeutic side the writer believes that the first type frequently calls for early collapse therapy: the "round" type requires repeated examinations at short intervals because of its rapid changes either toward healing or extension: the third type rarely heals completely and spontaneously, and, hence, it is this type which may need surgical collapse.

J. E. Habbe, M.D.

---

**Pulmonary Tuberculosis of Infants and Children. Rolla G. Karshner. Am. Jour. Roentgenol. and Rad. Ther., September, 1929, XXII, 226.**

This article deals with the various types of infantile and juvenile tuberculosis of the chest as studied by serial roentgenograms and checked in almost all instances by either necropsy or positive sputum diagnosis. The author considers the following forms: (1) primary tuberculous lesion occurring anywhere in either lung and seldom recognized during its active stage, (2) glandular tuberculosis, (3) hilum tuberculosis, (4) miliary tuberculosis, and (5) the rare adult form. In infants, tuberculous glandular disease often shows extensive shadows on the films, assuming the dimensions of neoplasms, but in older children the X-ray diagnosis of tuberculous hilum glands becomes increasingly difficult, and only

rarely can it be stated from the film study that the hilum changes are the cause of the symptoms present. The chief value of the X-ray examination is in being able to state definitely whether or not pulmonary involvement is present, although by careful serial study certain evidence can be obtained as to the progress of the glandular process. By hilum tuberculosis the author means a cheesy tuberculous involvement of the lung root tissues outside the glands, which frequently shows a triangular shadow on the film, with its base at the root and its apex directed toward the periphery. The prognosis in this type is bad. The adult form has never been seen by the author in children under ten years of age.

J. E. HABBE, M.D.

---

**Congenital Tuberculosis: Report of a Case. R. R. Struthers and H. G. Mitchell. Jour. Can. Med. Assn., September, 1929, XXI, 297.**

This is a case report of this comparatively rare condition in a child. The mother had died from acute generalized pulmonary tuberculosis twelve days after the child was born. The child lived seventy-eight days, with a continuous and advancing elevation of temperature after the thirty-sixth day. Six days before the child's death an X-ray examination of the chest showed miliary tuberculosis, with a pneumonic patch at the right base. At autopsy the lungs were found to be the site of a uniform and extensive tuberculous process. The liver, the spleen, and the mediastinal glands were all tuberculous, with considerable fibrosis in the liver. The history and findings furnished sufficient evidence to warrant the diagnosis of antenatal tuberculous infection.

L. J. CARTER, M.D.

---

**The Significance of Calcified Abdominal Lymph Nodes. Ross Golden and Robert J. Reeves. Am. Jour. Roentgenol. and Rad. Ther., October, 1929, XXII, 305.**

Tuberculosis of mesenteric lymph nodes is usually associated with clinical tuberculosis elsewhere, as in ileum and cecum or lungs, but may exist with no other lesions demonstrable at necropsy examination. Either the completely healed calcified nodes or those associated with caseation and an active infectious process may be productive of symptoms, usually attacks of colicky pain referred to the right lower quadrant. The pre-operative diagnosis can seldom be made positively without a roentgen demonstration of calcified nodes visualized on plain abdominal films. Such X-ray evidence may occasionally help to account for abdominal symptoms of long duration in a patient after disease of the appendix, gall bladder, and stomach have been excluded. The shadows are usually observed between the levels of the third lumbar and second sacral vertebra, and are more often in the right abdomen than in the left.

J. E. HABBE, M.D.

---

## CATHODE RAYS

**On the Effect of Cathode Rays upon the Resting Cells of *Salamandra Maculosa*. W. E. Pauli and G. Politzer. Zeitschr. Wissens. Biol. Abt. B: Zellforsch. und Mikrosk. Anat., 1929, VIII, 404.**

This is a research on the influence of cathode rays (C. H. F. Mueller equipment) upon the cornea of larvæ of *Salamandra maculosa* dyed with hemotoxilin, which was carried out in the Central Roentgen Institute and the Embryological Institute of the Vienna University. Changes in the cornea which appear shortly after radiation may be divided into three groups. Those in the first group show the necrotic changes of the resting cells, similar to the effect of other agents which act only upon the superficial layers. Therefore, they are not characteristic for the cathode rays. To the second group belong those karyokinetic changes which are produced by the roentgen rays, produced when the cathode rays are stopped by the window and within the tissue. In the third group are only those karyokinetic changes which are characteristic

for the cathode rays, *i.e.*, cells in which the chromosomes are clumped together, and in which there are fine threads dyed with hemotoxilin.

The following conclusions are drawn from the appearance of specific changes of the cells after the action of cathode rays: Cathode rays, which have recently been used therapeutically, possibly produce specific effects, which, however, must be investigated further. These effects differ from the effects of roentgen rays, and therefore cannot be compared with them. Differences in the effects of weakly filtered radium preparations and of roentgen rays are due to the effect of the beta rays, which are similar to the cathode rays, and, like these, probably produce characteristic effects. Frequently the opinion is expressed that roentgen rays act upon the tissue by the secondary beta or electron rays released in the tissue. If this were really the case, then the cell changes which are characteristic of cathode rays should also appear in the roentgen radiated cornea. Numerous experiments, however, show that in this case only those karyokinetic changes appear which are characteristic of roentgen rays and not those shown above which are due to cathode rays.

O. GLASSER, Ph.D.

---

## DOSAGE

**Permissible Radiation Exposure in Radiography and Fluoroscopy. Capt. T. W. Raison. U. S. Naval Med. Bull., January, 1930, XXVIII, 67.**

The number of radiographs and the amount of fluoroscopy that may be given without ill effects to the patient are questions of grave importance to the radiographer. While the limitations of the erythema dose are recognized, the skin toleration dose is the only satisfactory standard and to this all others should be compared. An erythema dose, or skin toleration dose, is the amount of radiation that will produce a defluvium of the scalp in three weeks, or a pronounced reddening of the skin in a young blonde on some sensitive area in about five to seven days after radiation. The erythema dose is an indefinite quantity and there are wide variations in susceptibility in different individuals, some patients developing an erythema with one-fourth the dose required by others. With the equipment at the U. S. Naval Hospital at San Diego, it was found that one E.S.D. was given by 87 K.V., 5 ma., 10 in. distance, in 140 secs. with broad focus Coolidge tube, without filter. Expressed in formula, 1 E.S.D. $= \frac{Ma \times V^2 \times T}{D^2} = \frac{5 \times 87^2 \times 140}{10 \times 10} = 52{,}983.$

This very closely approximates MacKee's erythema dose, at 8-inch distance, which is 57,600. The further work is based on MacKee's figure, and four-fifths of this, or 46,080, is taken as the largest amount of radiation permissible on any given area within three weeks' time. Beets and Arens' work on the effect of filtration is also utilized. The tables given by this author showing the number of radiographs permissible for the usual factors in use over various portions of the body are very interesting and helpful. Four exposures of the head can be made without screens and without filter, and with double screens and 0.5 mm. aluminum filter, 54 exposures can be made safely. With the Bucky diaphragm, 11 can be made safely with double screens and 0.5 mm. aluminum filter. It is interesting to note that nine films of the lateral spine can be made with the Bucky diaphragm and 0.5 mm. aluminum filter, over the same area (lumbar), without danger.

(NOTE:—The reviewer hails this information with great pleasure, as he has never felt safe in making more than two exposures of the lateral lumbar spine over the same area.)

W. W. WATKINS, M.D.

---

## EXPERIMENTAL STUDIES

**Experimental Investigations of the Roentgen-ray Effect on Bone Marrow. Annibale Casati. Strahlentherapie, 1929, XXXII, 721.**

The posterior legs of young rabbits were exposed to roentgen rays (140 K.V. effective, 3 ma., 40 cm. F.S.D., 0.5 Zn. + 2.0 Al., 400 r

on two successive days). The animals were killed ten, twenty, and forty days, respectively, following irradiation. Great care was taken in the fixation of the tissues in order to prevent any injuries to the nuclei. While previous investigators have reported a destructive effect manifesting itself within three hours following the exposure, the author found definite changes only two weeks after the treatment. No evidence was discovered pointing to a direct destruction of cells by roentgen rays. There seem to be changes in differentiation of the white blood corpuscles. The myelocytes differentiate into cells with segmented nuclei and the myeloblasts into fibrocytes. This may lead either to regeneration of the bone marrow or to its replacement by fibrous marrow, depending on the dose. The observed changes may be of therapeutic importance in agranulocytosis.

E. A. POHLE, M.D., PH.D.

---

**On the Possibility of Obtaining Highly Active Ergosterin (Vitamin D) from Raw Coffee. L. v. Noel and F. Dannmeyer. Strahlentherapie, 1929, XXXII, 769.**

With a new method, a substance was isolated out of coffee oil which appeared to be very rich in Vitamin D. Spectrophotometric tests and experiments on rats prove that its activity remains intact over half a year if kept under oil.

E. A. POHLE, M.D., PH.D.

---

## MEASUREMENT OF RADIATION

**The Physics of the Thimble Ionization Chamber: Second Communication. R. Braun and H. Küstner. Strahlentherapie, 1929, XXXII, 739.**

In this second article on the physics of the thimble ionization chamber, the authors investigate the saturation conditions. They describe a null method which permits the recording of saturation curves at high radiation intensities for a wide range of chamber potentials. The so-called "pin effect," reported in 1925, is obviously due to lacking saturation. Those interested in ionization measurements or the construction of ionization instruments will find valuable material in this paper.

E. A. POHLE, M.D., PH.D.

---

**Contribution to the Measuring Methods in Skin Therapy. F. Bödecker. Strahlentherapie, 1929, XXXII, 777.**

The author has studied the relation between wave length, Sabouraud-Noire dose, and r-units. He comes to the conclusion that for radition of about 120 K.V., no filter, 300 r; for 0.5 Al., 375 r; for 1.0 to 4.0 mm. Al. about 450 r to 485 r, correspond to the so-called normal dose.

E. A. POHLE, M.D., PH.D.

---

**Comparison of Roentgen and Radium Doses with a Roentgen Dosimeter. M. Jona. Strahlentherapie, 1929, XXXII, 775.**

The author undertook comparative measurements of roentgen rays and radium with a Wulf ionometer. He states that if radium is filtered through 2.6 mm. brass,

$$1 \text{ mgelh/cm.} = 6.5 \text{ r}$$

$$1 \text{ r} = 0.156 \pm 5 \text{ per cent mgelh/cm.}$$

E. A. POHLE, M.D., PH.D.

---

**Principles of Roentgenotherapy. I.—Fundamentals of Dosimetry. Ernst A. Pohle. Wisconsin Med. Jour., January 1, 1930, XXIX, 15.**

This is the first of a series of articles to appear in this journal, outlining the present status of roentgen therapy from a practical point of view.

Roentgen rays are a therapeutic agent and should, of course, be measured before they are administered to the human body. In the dosage two factors are of prime importance: the quality or penetration, and the quantity or amount of energy applied over a certain period of time. In examining into the quality of the roentgen rays, the factors of tube

potential and minimum wave length, spectrum, half value layer, absorption coefficient, effective wave length, and average wave length are discussed in this article.

W. W. WATKINS, M.D.

---

## ROENTGEN THERAPY

**Treatment of Uterine Hemorrhage by Irradiation of the Spleen. Felix Gál. Strahlentherapie, 1929, XXXII, 695.**

Roentgen rays directed to the spleen have proved of considerable help in the author's clinic, to stop uterine hemorrhage. One-third to three-fourths of an erythema dose is given over the splenic area; 160 K.V. to 180 K.V. filtered through 0.5 Zn. and 2.0 Al. was used. Other methods of treatment, for instance, drugs and organotherapy, should not be given up.

E. A. POHLE, M.D., PH.D.

---

**Roentgen Therapy in Climacteric Disturbances. J. Borak. Strahlentherapie, 1929, XXXIII, 142.**

Borak recommends the treatment of climacteric symptoms by roentgen rays directed to the hypophysis alone or also to the thyroid. Two temporal and one frontal field received 200 r (170 K.V., 0.5 Zn., 30 cm. F.S.D.) at three-day intervals. Sometimes the exposures were repeated two to four weeks later. In a number of cases additional exposures of the thyroid, with the same dose, improved the results.

E. A. POHLE, M.D., PH.D.

---

**On Roentgen Therapy of Inoperable Carcinoma of the Ovary. E. Vogt. Strahlentherapie, 1929, XXXII, 640.**

The author reports the histories of three patients suffering from carcinoma of the ovaries. The analysis of these cases leads him to the following conclusions:

The operability of a carcinoma of the ovary can be decided only by operation, that is, laparotomy; often it is possible to remove at least part of the tumor; following incomplete removal, X-ray therapy is indicated; the treatment should be started three to five days following operation, before ascites has formed again.

In two of the author's cases, laparotomy following X-ray therapy disclosed a definite effect of radiation on the tumor. In both cases, radical operation was made possible in originally inoperable patients. A second operation is sometimes more difficult, due to previous irradiation. Recurrence following operation should always be treated by roentgen irradiation. It is impossible to give a prognosis regarding the response of the tumor to irradiation. The method of choice in the author's clinic, in all cases of inoperable carcinoma of the ovary, is, therefore, laparotomy, drainage of the ascites, if present, and biopsy; this is followed by irradiation. No injurious effect of the biopsy has been observed.

E. A. POHLE, M.D., PH.D.

---

## WOUNDS (THERAPY)

**The X-ray Treatment of Wounds. Leopold Freund. Brit. Med. Jour., Sept. 7, 1929, No. 3,583, p. 449.**

It is the experience of many radiologists that the healing, not only of carcinomatous, sarcomatous, actinomycotic, venereal, tuberculous, and other ulcers, but also of old, neglected, sluggish, or badly healing wounds, can be hastened by the influence of X-rays. It has further been observed histologically that the hyperplasia of connective tissue in keloids arises from the numerous young round cells and spindle cells clustered around the blood vessels. With these facts in view, Professor Freund has evolved and recommends a method of treating such conditions as circumscribed patches of lupus vulgaris, epitheliomata, rodent ulcers, keloids, and pigmented nevi. These conditions are first excised surgically, thus removing masses of tissue which would otherwise weaken the rays by absorbing them on their way to the base of the

lesion. Thus the X-radiating of the fresh open wounds after operation renders the operation more effective, for if traces of the disease are left in the wound they will be attacked more intensely than when the wound is stitched up. Further, if in spite of this treatment some remaining trace of the disease gives rise to a circumscribed recurrence, this may be removed easily and quickly by the same method, because the thin, delicate, soft scar offers only a slight resistance to the breaking through of the newgrowth to the outside. This constitutes a very important advantage over wounds which have been stitched, and which offer insuperable obstacles to the breaking through of the infiltration which is growing beneath them and which spreads beneath the scar. In lupus vulgaris this method dispenses with the frequent applications of X-ray, which would be necessary if the lesion were not previously excised, with its concomitant dangers. By using this method a patch of lupus vulgaris the size of the palm of the hand can be fully healed in from six to eight weeks. The duration of the healing period for wounds after the application of X-rays of dosage a little higher than an epilation dose (about 6 to 7 H distributed over six or seven sittings at intervals of two or three days) is certainly no longer than it would be without X-ray. It would appear that unfiltered rays of 6 to 7 H hardness are more efficient than heavily filtered hard rays.

WALLACE D. MACKENZIE, M.D.

---

## SKIN (THERAPY)

**Action of X-rays on Healthy and Diseased Skin. Karl Linser. Fortschr. Therap., Feb. 25, 1929, Jahr., 5, Heft 4, p. 117.**

After a discussion of the physical-chemical effects of various types of radiation, the author comes to the conclusion that all types of radiation cause the same type of effect. Variations in these effects between hard and soft rays upon the skin are due to differences in their absorption. Roentgen rays have a destructive effect upon the different cells of the skin, especially upon their nuclei. The sensitivity of the cells is increased if inflammation is present. Gradual decrease of the sensitivity of the skin for light treatments does not occur in the case of X-ray treatments; with each successive treatment the skin becomes more sensitive.

OTTO GLASSER, PH.D.

---

**The Use of a Heavy Metal Filter in the Roentgen Treatment of Chronic Eczema. Sepp Grauer. Strahlentherapie, 1929, XXXII, 715.**

In 200 cases of chronic eczema treated by roentgen rays filtered through 0.36 Zn. + 2.0 Al., very satisfactory results were obtained. Each area was exposed at intervals of one week with 4 H, potential about 130 K.V., 4 ma., 30 cm. F.S.D. Careful observations did not reveal any bad effect in the deeper tissues.

E. A. POHLE, M.D., PH.D.

---

**The Results of Roentgen Therapy in Small Doses in Skin Diseases. H. Fuhs and Josef Konrad. Strahlentherapie, 1929, XXXII, 711.**

Two hundred forty-four cases of acne vulgaris, acne varioliformis, chronic eczema, erythema induratum, furunculosis, lupus vulgaris, psoriasis vulgaris, sycosis, and slow-healing ulcerations were treated with roentgen rays in doses of from 7 to 15 r, half value layer 0.1 to 0.14 mm. in Cu. In forty-six cases of acne rosacea, alopecia areata, mycosis fungoides, and pruritus the results were negative. It is suggested, therefore, that this method be given a trial because of its relative safety.

E. A. POHLE, M.D., PH.D.

---

**The Treatment of Dermatological Conditions with Grenz Rays. Herbert Fuhs. Strahlentherapie, 1929, XXXII, 704.**

In a number of skin diseases, "Grenz rays" produced at potentials of from 7 K.V. to 12

K.V. have proven of value. It is emphasized, however, that only the minimum dose necessary for the desired effect is to be given, to be repeated only as many times as absolutely indicated. No epilation was observed even after the application of high doses. The results in the various diseases are compiled in a table which should be looked up in the original article.

E. A. POHLE, M.D., PH.D.

## THYMUS (THERAPY)

**Thymic Asthma. Hugh Thursfield. Jour. Can. Med. Assn., March, 1929, XX, 239.**

The existence of a shadow in the region of the thymus gland has been accepted by some authorities as good evidence of enlargement of a pathological extent. That this is not correct has been shown by Blackfan and Little, who found shadows, which, according to the X-ray interpretation, were indicative of thymus glands, in 29 out of 60 infants who were not suffering from symptoms said to be characteristic of an enlarged thymus.

It is quite certain that shadows on the X-ray film simulating enlarged thymus may be caused by quite other structures, hence radiological evidence of the existence of an enlargement of the thymus gland must be accepted with the greatest caution.

There is such a condition as thymic asthma, but its occurrence is rare. When found, it is safer not to operate, for the operative mortality is heavy. X-ray treatment is effectual, giving a maximum of benefit for a minimum of risk.

L. J. CARTER, M.D.

**Changes of Pigmentation in Insects Caused by Quartz Light. Albrecht Hase. Arch. Dermatol. und Syphilis, 1929, Band 157, Heft 2, p. 437.**

Radiation of two types of wasps (*Nasonia brevicornis Ashm.* and *Dibrachys boucheanus Ratzbg.*) with various doses of ultra-violet light from a quartz mercury lamp retards and finally completely suppresses the formation of pigment on the eyes and on the body; on the breast less change in pigmentation is produced. Irregularities in the casting of the skin of the chrysalises were also observed after radiation. The experiments open a wide field for the study of problems of pigmentation in other insects, studies of the offspring and of heredity of radiated insects, effects of radiation on the visibility of the wasps, etc.

OTTO GLASSER, PH.D.

**Red as Antagonist of Ultra-violet. Fritz Ludwig and Julius v. Ries. Strahlentherapie, 1929, XXXII, 772.**

In experiments on rats, the authors demonstrated that Vigantol, which is ergosterin activated by ultra-violet radiation, can be inactivated by exposure to red light.

E. A. POHLE, M.D., PH.D.